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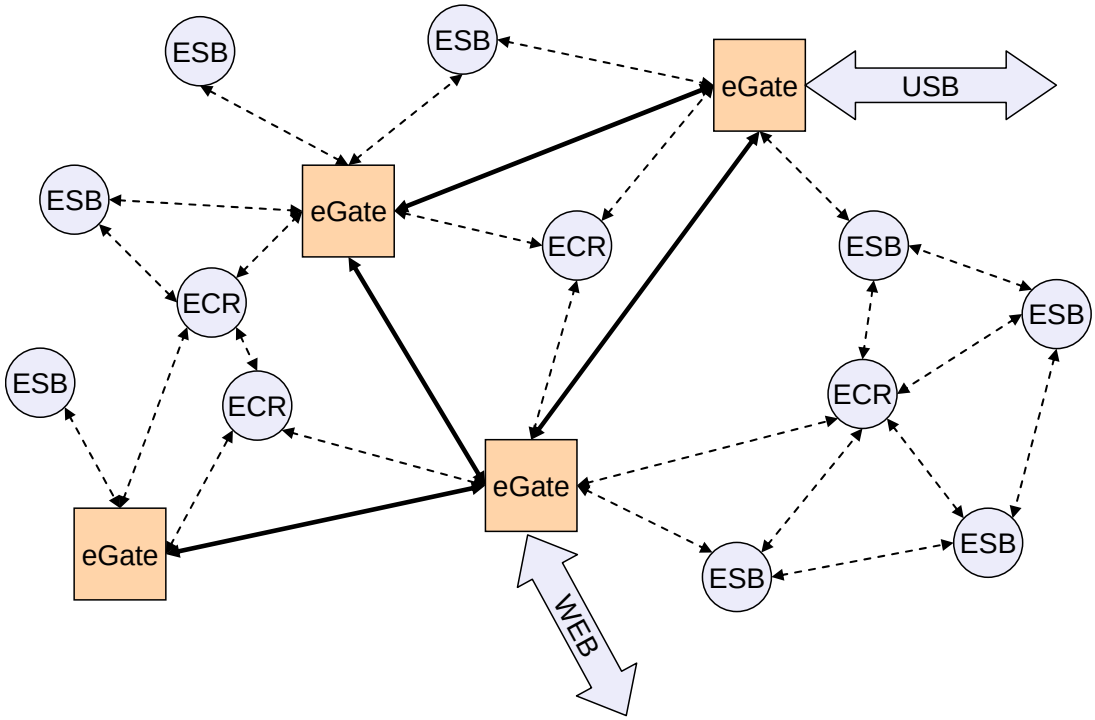
User Guide
(for ScatterWeb)

A platform for teaching & prototyping
wireless sensor networks



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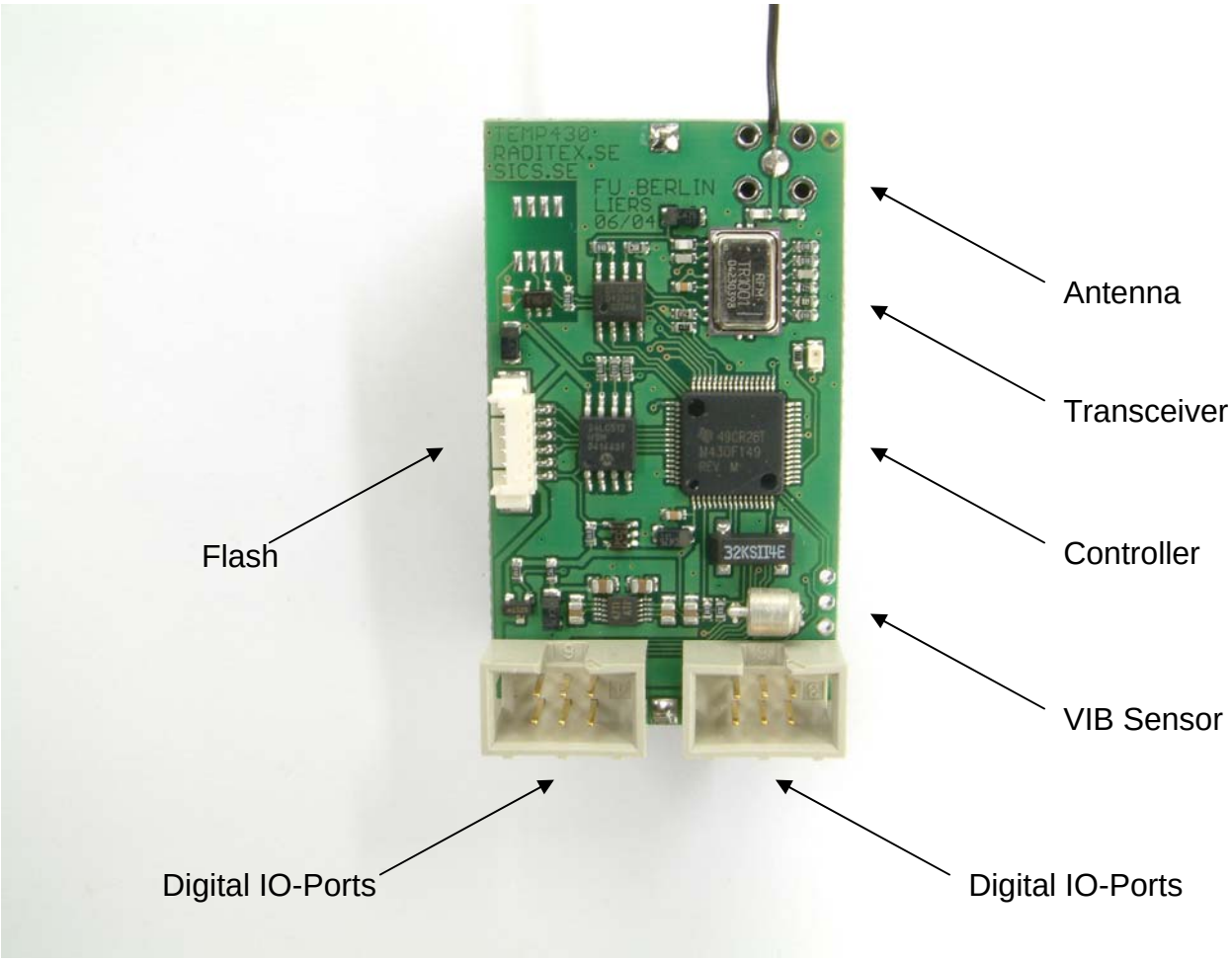
1 Platforms

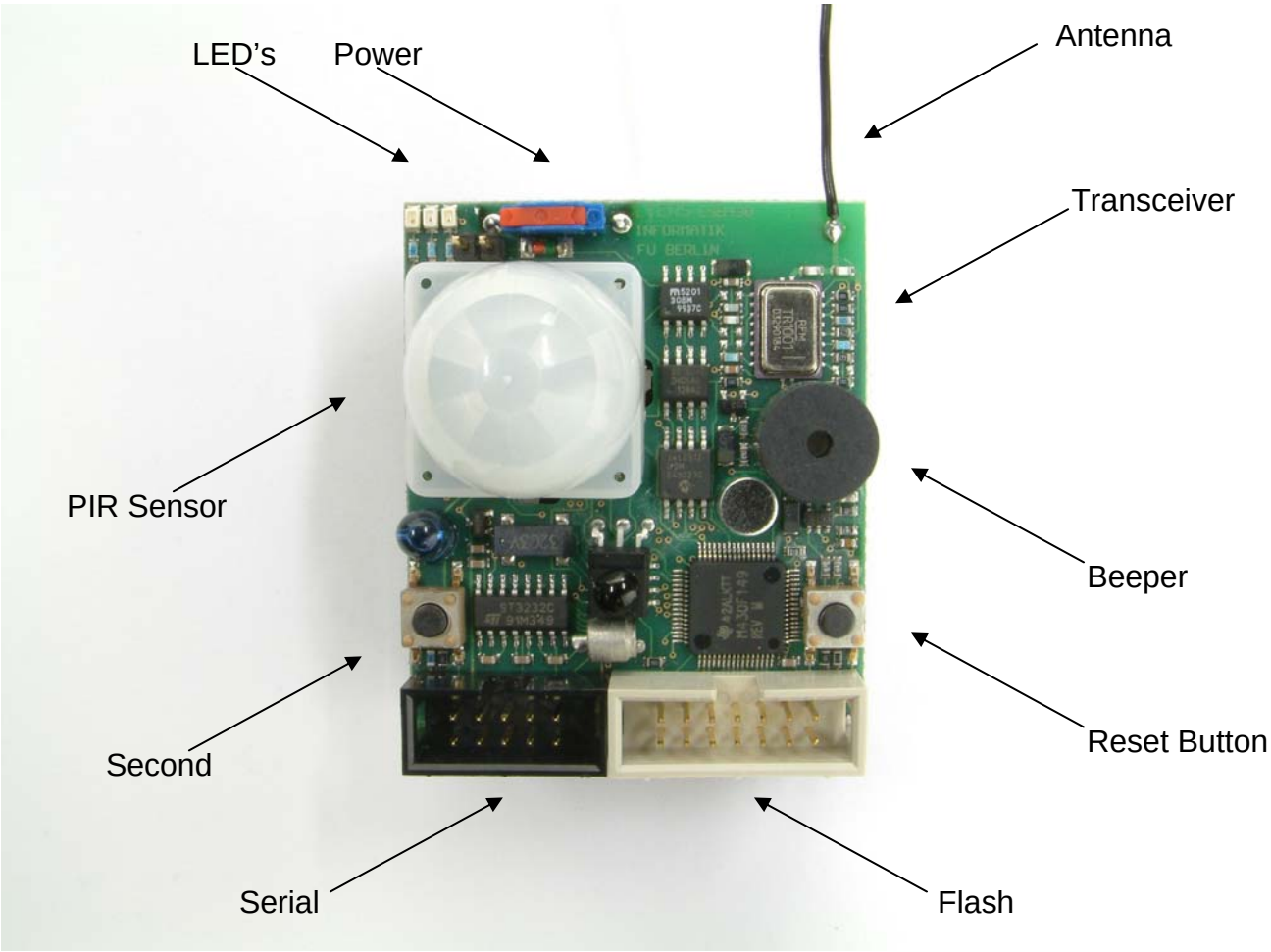
1.1 Embedded Chip Radio (ECR)



The ECR has additionally a Temperature Sensor, a red LED and a 64 Kbytes EEPROM.

Notice: You need an appropriate flash cable (obtainable on order) and the JTAG (also obtainable on order) to flash the ECR.

1.2 Embedded Sensor Board (ESB)



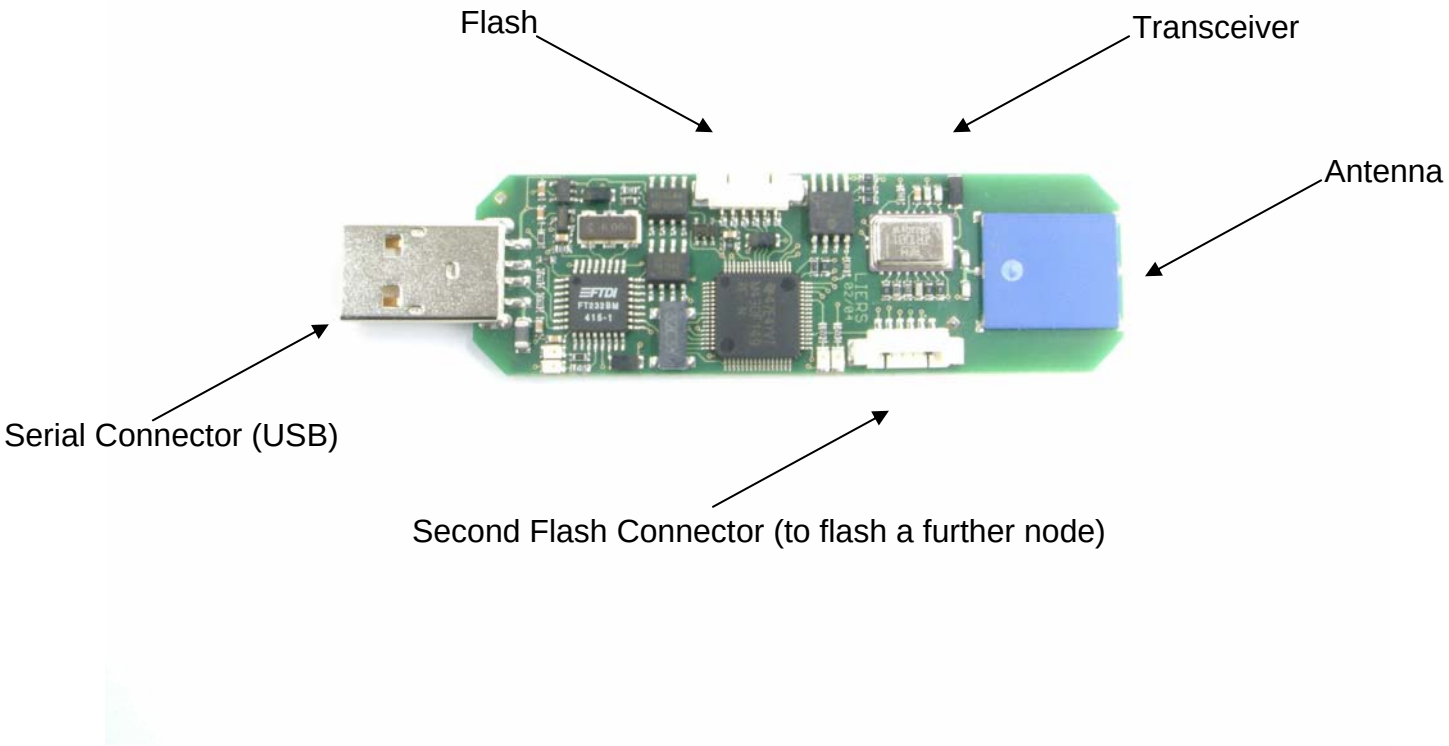
The ESB has additionally a Temperature Sensor, a VIB Sensor, IR to send and to receive, a Microphone and a 64 Kbytes EEPROM. The ESB supports the RC5-infrared-standard.

Notice: You need the JTAG (obtainable on order) to flash the ESB and an appropriate serial cable (also obtainable on order) to interconnect the ESB and the PC/PDA.

1.3 Embedded EYE (EYE)

The camera module has a serial connector to connect it to the ESB.

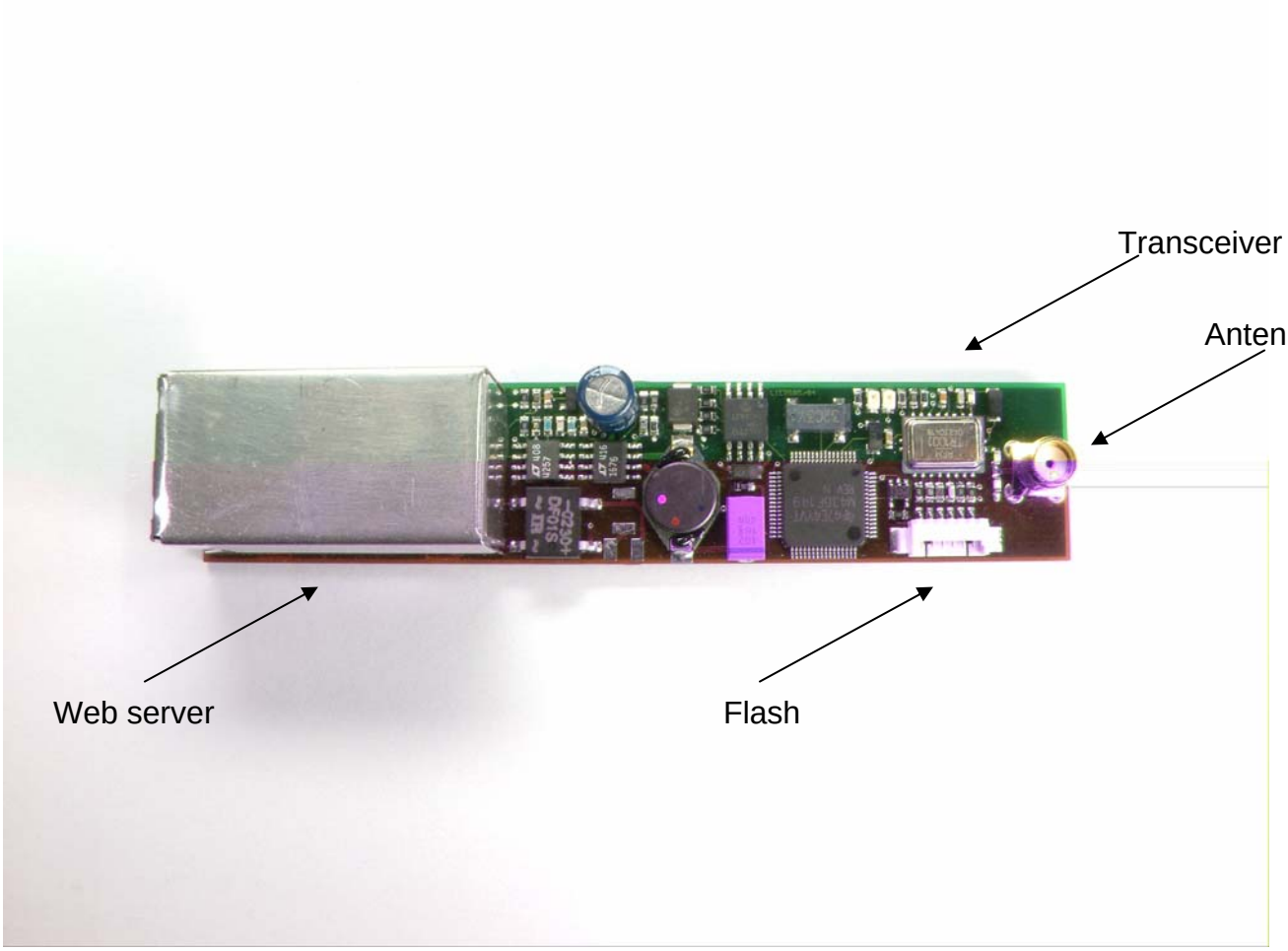
1.4 eGate/USB



The eGate/USB has additionally a red, a yellow and a green LED and a 64 Kbytes EEPROM.

Notice: You need an appropriate flash cable (obtainable on order) and the JTAG (also obtainable on order) to flash the eGate/USB.

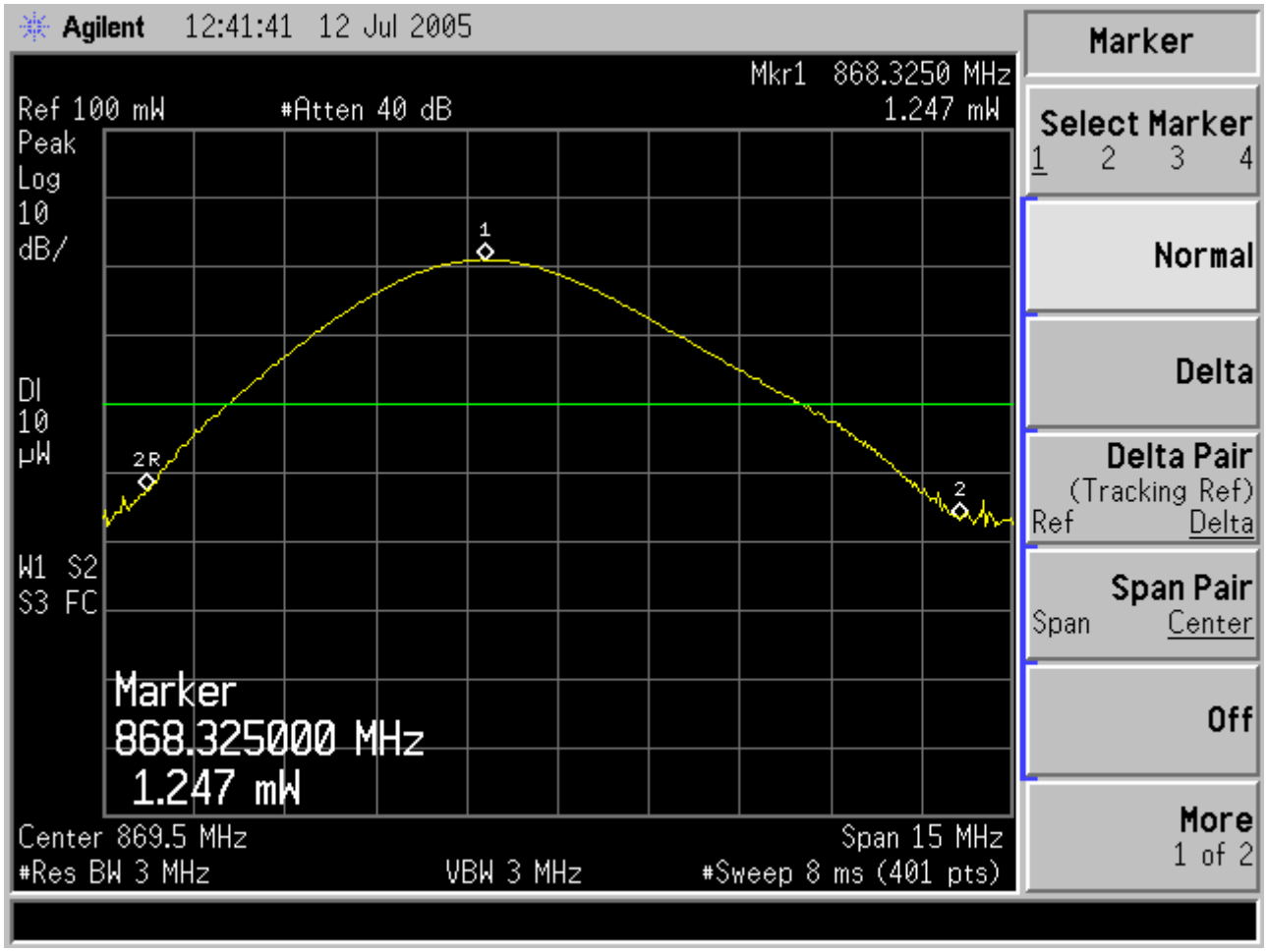
1.5 eGate/WEB

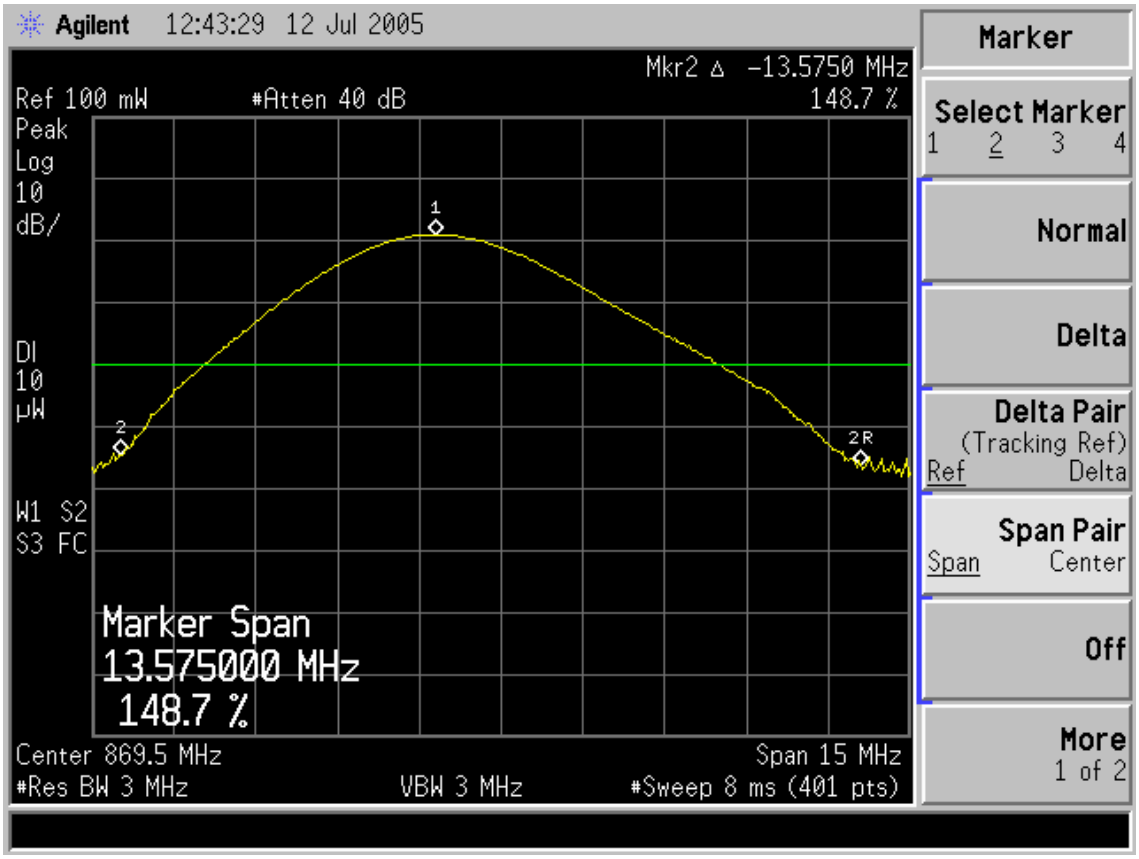


The eGate/WEB has additionally a red, a yellow and a green LED and a 64 Kbytes EEPROM.

Notice: You need an appropriate flash cable (obtainable on order) and the JTAG (also obtainable on order) to flash the eGate/WEB.

2 Radio communiction




Agilent 12:43:29 12 Jul 2005
Mkr2 Δ -13.5750 MHz
148.7 %
Ref 100 mW
#Atten 40 dB
Peak
Log
10
dB/
Dl
10
µW
W1 S2
S3 FC
Marker Span
13.575000 MHz
148.7 %
Center 869.5 MHz
Span 15 MHz
#Res BW 3 MHz
VBW 3 MHz
#Sweep 8 ms (401 pts)
Marker
Select Marker
1 2 3 4
Normal
Delta
Delta Pair
(Tracking Ref)
Ref Delta
Span Pair
Span Center
Off
More
1 of 2

3 ScatterWeb.API

As the name already implies, sensor networks need sensors, typically lots of sensors, to collect data from their environment. All sensor nodes may form an ad-hoc network with some nodes acting as data sources, some as relays, and some as data sinks collecting data. Nodes may act in all three roles at the same time. The ESBs developed by the CST Group forms a sound basis for research in sensor networks, the development of university level courses in CS/EE based on real hardware, and prototyping of sensor net applications. The ESBs are part of the ScatterWeb approach comprising a whole family of embedded web servers, sensors and actors. Typical communication scenarios of sensor networks based on the ESBs are:

- ESBs communicate via the serial port with a standard PC for application development.
- ESBs communicate with mobile phones via the serial port to connect to wide-area mobile phone networks. This enables remote configuration of ESBs via short messages (SMS) as well as reception of sensor data on arbitrary mobile phones world-wide.
- ESBs communicate via their radio interface with other ESBs or an embedded web server (EWS) to form a truly embedded, highly flexible sensor network solution.

Main components of the ESB are the sensors, a micro controller for processing of all data, and a transceiver handling communication with other nodes. Software for the following features is already available for the ESB 430:

- Configuration and analysis of all sensor data: vibration, noise, movement, temperature, infrared, (luminosity).
- Control of peripherals: timer, transceiver, serial port, EEPROM, IR-send/receive, LEDs, beeper, switches.
- Sending and receiving of data packets via the radio interface, transmission of sensor data, communication with other systems using the same radio interface (ESBs, ESWs).
- Sending and receiving of short messages (SMS) via connected mobile phone (serial port). Bluetooth connection available upon request (standard for the EWS). Just send the ESB an SMS triggering temperature monitoring every Tuesday morning from 7:00 a.m. until 11:43 a.m., if and only if there is movement in the room but no light - it's possible with a single SMS!
- Sending (e.g. to control home entertainment devices) and receiving (e.g. from conventional remote controls) of RC5 packets via infrared.

- Periodic polling of sensor data and (depending on settings) automatic transmission via the radio interface, the serial port (terminal or mobile phone).
- Simple and easy configuration and control of the ESB via terminal commands over the serial interface or radio.

Software

The software of the sensor nodes was first separated into two parts (firmware & application) to provide in-field programming via radio. This has recently changed because that reprogramming strategy created several problems. Now the whole thing (except the reprogramming code, which should not change anymore, see progamming.c) is reprogrammable. Anyway the separation between firmware and application is kept because it proved good as hardware abstraction layer and to provide some OS-like concepts. The Firmware provides abstract functions to interface and use the hardware, contains the main execution loop + interrupts and provides some OS-like concepts. The firmware supports all ScatterWeb/MSP430 devices: ESB (and EYE), eGate, ECR. The application (userapp, program) is built on top of the firmware.

Directory tree

- Applications: Contains application directories with PSPad project files.
- System: Contains firmware sources and binaries.

Major Changes

- Firmware and userapp are not that strictly separated anymore. This made reprogramming easier and all restrictions from the old firmware <-> userapp separation are gone. Reprogramming code is now in programming.h, flasher.h contains the radio transfer of code images.
- For simplicity all 3 firmwares from ESB, EYE, eGate and ECR have been integrated into one with the use of #ifdef at some hardware dependent places. When compiling the command line one must always define one of: ESB, eGate, ECR, EYE. This is done in the makefiles with the variable DEVICE. The makefiles are now taking every source file they see in the directories and don't need to be changed for new/removed files anymore (Look into the makefiles and at new directory structure).
- Radio software has changed. Sending is now also done interrupt driven and comes with a ring buffer to store several packets to send. Additional new features are crc16 checksums and automatic acknowledgements (except broadcasts) with feedback to the sender of every packet.

- The terminal software has been moved to the firmware as many commands between devices were the same. Command creation has changed and most commands are executable from a remote device (with reply). Commands can now be placed where they are needed, Macros and a special section in flash build a table to automatically search all commands (See ScatterWeb.Messaging.h).
- Light sensor software has been removed due to complex handling. Timer slots are also needed for constant dco checking & adjusting (ScatterWeb.Timers.h) and a software RTC (ScatterWeb.Time.h) as the RTC is mostly abandoned because of its big current usage, it's only used as an well calibrated temperature sensor (ScatterWeb.System.h).
- ScatterWeb.Time.h represents the new software RTC (see currentTime). ScatterWeb.System.h has been completely cleared; only the function for reading the temperature and ensuring RTC 32 kHz output at initialization are left. fiveMsTimer is replaced through currentTime or use of timers (ScatterWeb.Timers.h), its still left for internal timer use.
- ScatterWeb.Timers.h module has been added, no need to poll for an elapsed time anymore. ScatterWeb.System.h includes DCO checking, so DCO is recalibrated the whole time, not at startup only!
- Other modules have been more separated (ScatterWeb.Configuration.h (was in ScatterWeb.IO.h), programming.h (was in flasher.h)).
- The watchdog has been rewritten. It's now correct and possible to see where a reset came from. Additionally a feature has been added to watch stack growth and detect a stack overflow. For bad conditions like that a panic function has been added. The firmware can disable the application if a panic occurred.
- An abstract printf like function has been implemented for string outputting: String_abstractWrite. This is used by the functions String_write (to write a string to memory), Comm_print (to write normal output to the serial port) and Comm_log (to write debug output to the serial port). No other methods should be used for writing to the serial port, sendRS232 is not public anymore. This is because serial port output is now controlled via Comm_logLevel. It allows several log levels; some debug bits for special debugging and total disabling of all output (see ScatterWeb.Comm.h).
- A cooperative scheduler exists to create simple task functions: ScatterWeb.Threading.h.
- The main super loop goes to sleep when everything is processed, all things that need to be handled are interrupt-driven (see main). Every interrupt which needs processing from the super loop wakes the processor up with WAKEUPLPM1, which also sets a flag in runModule. When all flags in runModule are reset (after processing from super loop tasks) the loop goes to LPM1 again. If a function which needs calls as often as possible is added to the super loop you have to comment out the lines about sleeping!
- Typedefs for UINT8, UINT16, UINT32 have been introduced because it is better style and much shorter.

Important things to know:

- All routines should return fast. If a routine occupies the processor for a long time (for example outputting a long text which works with the blocking sendRS232Char() function) it should call System_startWatchdog() repeatedly (normally done in main()) to avoid a watchdog reset. If a watchdog reset occurs the firmware will disable the programm if PANIC_DISABLES_USERAPP is set.
- You don't need to change the makefiles anymore. Makefiles in firmware and application automatically compile every .c file in the src directories and look into every .c and .h file for changes.
- No initialization of global values is done. You can write "UINT16 var = 49;" but var will never be initialized, do initialization in code! (Initialization may work again if the standard startup routine is used.)
- Don't use dynamic memory allocation (malloc/free)! Dynamic memory allocation bears the following problems on MCUS:

    - Much harder to debug.
    - Unknown behavior at compile time.
    - Memory fragmentation and no way (missing MMU) to defragment it.
    - No memory protection between stack and heap which grow towards each other.
    - Additionally current msp430-gcc malloc implementation seems to be buggy.

Sometimes an embedded engineer said: "Think small on MCUs. If you are planning to use dynamic memory allocation, you are thinking much too BIG."

- If weird things happen look into linker map "out.map"
- Sometimes compilation fails or hangs with existing objects files from another machine.

Do a "make clean" or simply delete all object (*.o) files in firmware and userapp directories in this situation!

3.1 ScatterWeb.Comm

\ScatterWeb 2.x\System\src\ScatterWeb.Comm.h:

```
#ifndef ScatterWeb_Comm
#define ScatterWeb_Comm
  #define BPS_2400       (0x01)
  #define BPS_14400      (0x02)
  #define BPS_19200      (0x03)
  #define BPS_38400      (0x04)
  #define BPS_57600      (0x05)
  #define BPS_115200     (0x06)
  UINT8 Comm_logLevel;
  bool Comm_init(UINT8 bps);
  bool Comm_print(const char *fmt, ...);
  bool Comm_log(UINT8 level, const char* fmt, ...);
  bool Comm_on();
  bool Comm_off();
  bool Comm_registerByteLevel(fp_char_t fp);
  bool Comm_clear();
#endif
```

The ScatterWeb.Comm represents the standard output for applications. The init function for the UART Comm_init() provides setup for all standard baud rates: BPS_2400, BPS_14400, BPS_19200, BPS_38400, BPS_57600, and BPS_115200. All UART communication should be done with Comm_print() or Comm_log() as the serial output with this functions is controlled via Com_logLevel and struct Configuration.boot_logLevel in ScatterWeb.Configuration. All sending functions are blocking. Receiving is handled by an interrupt and you can choose byte-access or line-access.

- byte-access: To gain access to the byte level, register a function that expect to get pass an UINT8 as parameter (see Comm_registerByteLevel(fp_char_t fp)).
- line-access: To gain access to the line level, register a function that expect to get pass an void* as parameter (see C_SERIAL and System_registerCallback(UINT8 type, void(*fp_t)())). If the line is handled the receiving function should call Comm_clear().

```
bool Comm_init(UINT8 bps);
```

Function: Initializes the serial

Parameter: bps - the bps to be set

Return value: <code>True</code> always.

```
bool Comm_print(const char *fmt, ...);
```

Function: Sends bytes of data

Parameter: fmt - function

... - list of parameters

Return value: <code>True</code> if serial is on;

<code>False</code> otherwise.

```
bool Comm_log(UINT8 level, const char* fmt, ...);
```

Function: Sends bytes of log data

Parameter: level - log level

fmt - function

... - list of parameters

Return value: <code>True</code> if serial is on;

<code>False</code> otherwise.

```
bool Comm_on();
```

Function: Switches the serial on

Parameter: None

Return value: <code>True</code> always.

```
bool Comm_off();
```

Function: Switches the serial off

Parameter: None

Return value: <code>True</code> always.

```
bool Comm_registerByteLevel(fp_char_t fp);
```

Function: Registers byte level and will be set by Comm_init(UINT8 bps)

Parameter: Fp -pointer of function

Return value: <code>True</code> if ECR or ESB defined

<code>False</code> if eGate defined.

```
bool Comm_clear();
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

3.2 ScatterWeb.Configuration

\ScatterWeb 2.x\System\src\ScatterWeb.Configuration.h:

```
#ifndef ScatterWeb_Configuration
#define ScatterWeb_Configuration
  #define EADR_CONFIG               (0x0F00)
  #define DEBUG_RADIO               (0x80)
  #define DEBUG_DCO                 (0x40)
  #define DEBUG_SYNC                (0x20)
  #define NO                        (0x01)
  #define LOW                       (0x02)
  #define MEDIUM                    (0x03)
  #define HIGH                      (0x04)
  #define VERBOSE                   (0x05)
  #define PANIC_ON_STACK_OVERFLOW   (0x01)
  #define PANIC_ON_FULL_TIMERS      (0x02)
  #define PANIC_ON_BAD_RESET        (0x04)
  #define PANIC_DISABLES_APP        (0x80)
  #define FF_PROGRAMMABLE           (0x01)
  #define FF_DCOCHECKER             (0x02)
  typedef struct {
      UINT16 id;
      UINT16 rxReceiveLimit;
      UINT8 transmitPower;
      UINT8 boot_logLevel;
      UINT8 panicFlags;
      UINT8 firmwareFlags;
  } config_t;
  extern config_t Configuration;
  bool Configuration_init();
  bool Configuration_save();
  bool Configuration_print();
#endif
```

The ScatterWeb.Configuration provides functions that allow you to programmatically access configuration settings. The configuration consists of the struct config_t defined in ScatterWeb.Configuration.h. The variable Configuration is of that type and represents the current config in RAM and can be accessed directly every time. Changes to Configuration will only be made

permanent (power-off & resets) with a call to Configuration_save(), which copies the content of the Configuration to EEPROM[EADR_CONFIG]. Initial loading from EEPROM[EADR_CONFIG] is done by Configuration_init() and has to be called on initialization in main().

First time configuration

Uncomment the following definition of firstTimeConfig and it will get laid into Infomem (0x1000-0x1100, see .hex-File). Before Configuration_init() loads the regular config from EEPROM, it checks if the first int (which corresponds to the id) in Infomem is not 0xFFFF. If it is not, it copies the configuration from Infomem to EEPROM (clearing Infomem afterwards and loading the newly written data from EEPROM to Configuration).

```
bool Configuration_init();
```

Function: Initializes configuration settings for the configuration section

Parameter: None

Return value: <code>True</code> always.

```
bool Configuration_save();
```

Function: Saves configuration settings for the configuration section

Parameter: None

Return value: <code>True</code> always.

```
bool Configuration_print();
```

Function: Prints configuration settings for the configuration section

Parameter: None

Return value: <code>True</code> always.

3.3 ScatterWeb.Data

\ScatterWeb 2.x\System\src\ScatterWeb.Data.h:

```
#ifndef ScatterWeb_Data
#define ScatterWeb_Data
  #include "ScatterWeb.Time.h"
  #define REDSTATE            (Data_redLed())
  #define YELLOWSTATE         (Data_yellowLed())
  #define GREENSTATE          (Data_greenLed())
  #define SENSOR_MOVEMENT     (0x08)
  #define SENSOR_VIBRATION    (0x10)
  #define SENSOR_BUTTON       (0x80)
  #define SENSOR_MICROPHONE   (0x01)
  #define SENSOR_TEMPERATURE  (0x02)
  #define SENSOR_RC5          (0x04)
  #define SENSOR_VOLTAGE      (0x40)
  typedef struct {
      UINT16 id;
      UINT8 sensor;
      time_t timeStamp;
      UINT16 value;
  } sdata_t;
  extern UINT8 sensorFlags;
  bool Data_init();
  bool Data_batteryOn(UINT16 interval, UINT16 thresh);
  bool Data_batteryOff();
  bool Data_beeperOn();
  bool Data_beeperOff();
  bool Data_beeperToggle();
  bool Data_buttonOn(UINT16 delay);
  bool Data_buttonOff();
  bool Data_greenOn();
  bool Data_greenOff();
  bool Data_greenToggle();
  bool Data_redOn();
  bool Data_redOff();
  bool Data_redToggle();
  bool Data_yellowOn();
```

```
  bool Data_yellowOff();
  bool Data_yellowToggle();
  bool Data_microphoneOn(UINT16 delay, UINT16 diff);
  bool Data_microphoneOff();
  bool Data_movementOn(UINT16 delay);
  bool Data_movementOff();
  bool Data_temperatureOn
      (UINT16 interval, UINT16 range, UINT16 diff, UINT16 spd);
  bool Data_temperatureOff();
  bool Data_vibrationOn(UINT16 delay);
  bool Data_vibrationOff();
  bool Data_greenLed();
  bool Data_redLed();
  bool Data_yellowLed();
  bool Data_RC5SendPHI(int data);
  bool Data_RC5Enable();
  bool Data_RC5Disable();
  bool Data_RC5SendNEC(UINT16 data1, UINT16 data2);
  bool Data_sensorHandler();
  void Data_RC5ReceiveHandler();
  void Data_RC5EventHandler();
#endif
```

The ScatterWeb.Data consists mostly of the functions that constitute the sensors architecture. The sensors architecture enables you to build components that efficiently manage data from multiple data sources. It provides the tools to initialize, enable, and disable data in this multiple tier system. To get sensor events you must set a callback function in System_callbacks[C_SENSOR], for disabling that set System_callbacks[C_SENSOR] = NULL. Each sensor is separately enabled and disabled with its enable/disable function. The enable function takes some sensor specific arguments. The first argument is the interval (or debounce delay) for reading the sensor internally, it can also be seen as a reaction time (for example for Vib: If Vibration has been signaled how long the sensor must stay silent to signal NoVibration?).

For temperature 4 arguments are needed to specify a funnel function: Data_temperatureOn(Interval, StartRange, Diff, StepsPerDiff):

- Interval - How often is the temperature read in systems ticks (~1ms).
- StartRange - How much must the temperature differ from the last value to get signaled.
- Diff - How much the Range is decreased every DiffStep measures.
- StepsPerDiff - How much measures until Range is decremented with Diff.

Attention: Temperature data is in fixed point 2s complement format!!!

This approach also includes simple standard evaluation methods:

- Periodic Reading: To signal every x ms do Data_temperatureOn(x, 0, 0, 0);
- On change Reading: To signal only on temperature changes greater than x (temperature is read every y ms) do Data_temperatureOn(y, x, 0, 0):
- Periodic & On Change combined: To signal on every change greater than x or after a time y*z has passed (temperature is read every z ms) do Data_temperatureOn(z, x, x, y).

Examples:

- Data_temperatureOn(5120, 0, 0, 0) - Every 5 seconds.
- Data_temperatureOn(2048, 0x0080, 0, 0) - Only on change greater 1°C (temperature is read every 2 seconds).
- Data_temperatureOn(6144, 0x0080, 0x0080, 20)- Every 20*6s=2min or if changed more than 1°C (temperature is read every 6 seconds).
- Data_temperatureOn(6144, 0x0200, 0x0040, 10) - Funnel function: Measure every 6 seconds and decrease range from 2°C for 0,5°C every 10*6s=1min (temperature is read every 6 seconds).

Power for sensors (and RS232 voltage converter) must be enabled, see System_powerOn() / System_powerOff(). The IR Receiver is handled in file ScatterWeb.Data.c. A good example for using the sensors is ScatterWeb.Event.c in [EMPTY]\ESB project. It’s controlling the beeper. It’s receiving RC5 via IR Receiving Diode.

RC5: 1780us bit length (Manchester encoded, so half bit length of 890us is important). Transferred packet (2 start + toggle bit + 5 address bits + 6 command bits)):

| S | S | T | A4 | A3 | A2 | A1 | A0 | C5 | C4 | C3 | C2 | C1 | C0 |

irdata format:

| ? | ? | error | newData | T | A4 | A3 | A2 | A1 | A0 | C5 | C4 | C3 | C2 | C1 | C0 |

Some common addresses and commands:

Address:	Device:	Command:	
0	TV1	0...9	Numbers 0...9 (channel select)
1	TV2	12	Standby
5	VCR1	16	Master Volume +
6	VCR2	17	Master Volume -
17	Tuner	18	Brightness +
18	Audio Tape	19	Brightness -
20	CD Player	50	Fast rewind
		52	Fast run forward
		53	Play
		54	Stop
		55	Recording

It supports methods for sending with IR diode. These methods are timed to the system clock (4505600 MHz) and disable all interrupts and so will halt the system timer for some milliseconds. Radio packet transmission & reception are also disrupted.

```
bool Data_init();
```

Function: Initializes the sensors

Parameter: None

Return value: <code>True</code> if sensors available;
<code>False</code> otherwise.

```
bool Data_batteryOn(UINT16 interval, UINT16 thresh);
```

Function: Enables the battery sensor

Parameter: interval - interval of measurement
thresh - thresh of measurement

Return value: <code>True</code> if battery sensor available;
<code>False</code> otherwise.

```
bool Data_batteryOff();
```

Function: Disables the battery sensor

Parameter: None

Return value: <code>True</code> if battery sensor available;
<code>False</code> otherwise.

```
bool Data_beeperOn();
```

Function: Enables the beeper

Parameter: None

Return value: <code>True</code> if beeper sensor available;
<code>False</code> otherwise.

```
bool Data_beeperOff();
```

Function: Disables the beeper

Parameter: None

Return value: <code>True</code> if beeper sensor available;
<code>False</code> otherwise.

```
bool Data_beeperToggle();
```

Function: Toggles the beeper

Parameter: None

Return value: <code>True</code> if beeper sensor available;
<code>False</code> otherwise.

```
bool Data_buttonOn(UINT16 delay);
```

Function: Enables the button

Parameter: delay - delay of measurement

Return value: <code>True</code> if button sensor available;
<code>False</code> otherwise.

```
bool Data_buttonOff();
```

Function: Disables the button

Parameter: None

Return value: <code>True</code> if button sensor available;
<code>False</code> otherwise.

```
bool Data_greenOn();
```

Function: Enables the green LED

Parameter: None

Return value: <code>True</code> if green led available;
<code>False</code> otherwise.

```
bool Data_greenOff();
```

Function: Disables the green LED

Parameter: None

Return value: <code>True</code> if green led available;
<code>False</code> otherwise.

```
bool Data_greenToggle();
```

Function: Toggles the green LED

Parameter: None

Return value: <code>True</code> if green led available;
<code>False</code> otherwise.

```
bool Data_redOn();
```

Function: Enables the red LED

Parameter: None

Return value: <code>True</code> if red led available;
<code>False</code> otherwise.

```
bool Data_redOff();
```

Function: Disables the red LED

Parameter: None

Return value: <code>True</code> if red led available;
<code>False</code> otherwise.

```
bool Data_redToggle();
```

Function: Toggles the red LED

Parameter: None

Return value: <code>True</code> if red led available;
<code>False</code> otherwise.

```
bool Data_yellowOn();
```

Function: Enables the yellow LED

Parameter: None

Return value: <code>True</code> if yellow led available;
<code>False</code> otherwise.

```
bool Data_yellowOff();
```

Function: Disables the yellow LED

Parameter: None

Return value: <code>True</code> if yellow led available;
<code>False</code> otherwise.

```
bool Data_yellowToggle();
```

Function: Toggles the yellow LED

Parameter: None

Return value: <code>True</code> if yellow led available;
<code>False</code> otherwise.

```
bool Data_microphoneOn(UINT16 delay, UINT16 diff);
```

Function: Enables the microphone sensor

Parameter: delay - delay of measurement
diff - diff of measurement

Return value: <code>True</code> if microphone sensor available;
<code>False</code> otherwise.

```
bool Data_microphoneOff();
```

Function: Disables the microphone sensor

Parameter: None

Return value: <code>True</code> if microphone sensor available;
<code>False</code> otherwise.

```
bool Data_movementOn(UINT16 delay);
```

Function: Enables the movement sensor

Parameter: delay - delay of measurement

Return value: <code>True</code> if movement sensor available;
<code>False</code> otherwise.

```
bool Data_movementOff();
```

Function: Disables the movement sensor

Parameter: None

Return value: <code>True</code> if movement sensor available;
<code>False</code> otherwise.

```
bool Data_temperatureOn(UINT16 interval, UINT16 range, UINT16 diff,
UINT16 spd);
```

Function: Enables the temperature sensor

Parameter: interval - interval of measurement
range - range of measurement
diff - diff of measurement
spd - spd of measurement

Return value: <code>True</code> if temperature sensor available;
<code>False</code> otherwise.

```
bool Data_temperatureOff();
```

Function: Disables the temperature sensor

Parameter: None

Return value: <code>True</code> if temperature sensor available;
<code>False</code> otherwise.

```
bool Data_vibrationOn(UINT16 delay);
```

Function: Enables the vibration sensor

Parameter: delay - delay of measurement

Return value: <code>True</code> if vibration sensor available;
<code>False</code> otherwise.

```
bool Data_vibrationOff();
```

Function: Disables the vibration sensor

Parameter: None

Return value: <code>True</code> if vibration sensor available;
<code>False</code> otherwise.

```
bool Data_greenLed();
```

Function: Returns the state of the green LED

Parameter: None

Return value: <code>True</code> if green Led is switched on;
<code>False</code> otherwise.

```
bool Data_redLed();
```

Function: Returns the state of the red LED

Parameter: None

Return value: <code>True</code> if red Led is switched on;
<code>False</code> otherwise.

```
bool Data_yellowLed();
```

Function: Returns the state of the yellow LED

Parameter: None

Return value: <code>True</code> if yellow Led is switched on;
<code>False</code> otherwise.

```
bool Data_RC5SendPHI(int data);
```

Function: Sends a RC5 PHI command

Parameter: data - data to send

Return value: <code>True</code> True if IR sensor available;
<code>False</code> otherwise.

```
bool Data_RC5Enable();
```

Function: Enables the RC5

Parameter: None

Return value: <code>True</code> True if IR sensor available;
<code>False</code> otherwise.

```
bool Data_RC5Disable();
```

Function: Disables the RC5

Parameter: None

Return value: <code>True</code> True if IR sensor available;

<code>False</code> otherwise.

```
bool Data_RC5SendNEC(UINT16 data1, UINT16 data2);
```

Function: Sends a RC5 NEC command

Parameter: data1 - data1 to send

data2 - data2 to send

Return value: <code>True</code> True if IR sensor available;

<code>False</code> otherwise.

```
bool Data_sensorHandler();
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

```
void Data_RC5ReceiveHandler();
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

```
void Data_RC5EventHandler();
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

3.4 ScatterWeb.IO

\ScatterWeb 2.x\System\src\ScatterWeb.IO.h:

```
#ifndef ScatterWeb_IO
#define ScatterWeb_IO
  #define EEPROMADDRESS (0x00)
  #define EEPROMPAGEMASK (0x7F)
  bool IO_erase(UINT16 e_adr, UINT16 size);
  UINT8* IO_read(UINT16 e_adr, UINT8* r_adr, UINT16 size);
  bool IO_write(UINT16 e_adr, UINT8* r_adr, UINT16 size);
#endif
```

The ScatterWeb.IO contains functions that allow reading and writing to the EEPROM. Most important functions for writing/reading the EEPROM are IO_write() / IO_read(). The EEPROM offers 64k-memory (100000 write cycles) and is accessed with an I2C like bus. Currently use is storing configuration data (see ScatterWeb.Configuration.c) and temporary storage of a new software image before it gets flashed. (DEVICE ADDRESSING: Start | 1 0 1 0 A2 A1 A0 R/W | ...)

EEPROM memory map:

Region – Usage

- 0x0000 - 0x0CFF - Free for use.
- 0x0D00 - 0x0DFF - Application config (EADR_APPCONFIG).
- 0x0E00 - 0x0EFF - Used by flasher.c / EADR_FLASHERBUF: Free for use only if flasher_state==IDLE
- 0x0F00 - 0x0FFF - Never change something here. Used for configuration data (ScatterWeb.Configuration.c, EADR_CONFIG) and some reprogramming variables.
- 0x1000 - 0xFFFF - Programming image storage or other big data. Use according to EEPROM[EADR_IMAGESTATE].

```
bool IO_erase(UINT16 e_adr, UINT16 size);
```

Function: Erase several bytes from EEPROM (means set them to 0xFF).

Parameter: e_adr - start address of bytes to erase

size - size of bytes to erase

Return value: <code>True</code> if erase successful;

<code>False</code> otherwise.

```
UINT8* IO_read(UINT16 e_adr, UINT8* r_adr, UINT16 size);
```

Function: Reads size bytes from the EEPROM, uses sequential read (faster than readEEPROMByte).

Parameter: e_adr - start address of bytes to read

r_adr - array to store read bytes

size - size of bytes to read

Return value: UINT8* pointer of r_adr

```
bool IO_write(UINT16 e_adr, UINT8* r_adr, UINT16 size);
```

Function: Writes size bytes to the EEPROM, uses sequential write (faster than writeEEPROMByte).

Parameter: e_adr - start address of bytes to write

r_adr - array of bytes to write

size - size of bytes to write

Return value: <code>True</code> if write successful;

<code>False</code> otherwise.

3.5 ScatterWeb.Messaging

\ScatterWeb 2.x\System\src\ScatterWeb.Messaging.h:

```
#ifndef ScatterWeb_Messaging
#define ScatterWeb_Messaging
  #define SERIALONLY     (0x02)
  #define COMMAND(x, flags)  void term_##x (const UINT8* str); \
      __attribute__((section(".commands")))
      const command_t com_##x = { term_##x, #x, flags }; \
      void term_##x (const UINT8* str)
  typedef void(*fp_term)(const UINT8*);
  extern UINT8 term_reply[TERM_BUFSIZE];
  typedef struct command_struct {
      fp_term function;
      UINT8 code[3];
      UINT8 flags;
  } command_t;
  bool Messaging_on();
  void Messaging_serialHandler();
  bool Messaging_requestHandler();
  bool Messaging_answerHandler();
  bool Messaging_requestDataHandler(UINT8* data);
#endif
```

The ScatterWeb.Messaging provides functions that allow you to connect to, monitor, and message on the network and send, receive, or peek messages. Control the MSP via RS232 or radio with simple ASCII commands.

Remote command execution

To issue an command over radio write @[id], answers will get [id] prep ended.

@85 rid

[85] 85

@85 tim

[85] 23080608,984 2001-09-25 03:16:48

Command creation

Use the COMMAND macro to easily create a new terminal command. The first argument to the Macros is always the three digit terminal command code. The second argument to the Macros is a 8bit flag field. For example the following:

```
COMMAND(xxx, 0){ print("test\r\n"); }
```

will evaluate to:

```
void term_xxx (const UINT8* str);
__attribute__((section(".commands"))) const command_t com_xxx = { term_xxx, "xxx", 0 };\
void term_xxx (const UINT8* str) { print("test\r\n"); }
```

Besides creating the function header it first creates a forward declaration which is then needed in the following definition of a const command_t com_xxx struct in the .commands segment. com_xxx contains a pointer to the function, the three digit function code and a flag field. Because all those command_t entries are put into a special segment (.commands), the function doCommand can easily loop through this segment (going from __term_start to __term_end also provide by the linker script) and search for the command. This even makes it possible, to declare terminal commands where needed, not only in ScatterWeb.Messaging.c! (The firmware commands will still stay centralized in ScatterWeb.Messaging.c to have code & documentation of the firmware commands in one place.)

The needed modifications of the linker script can be seen in System/ldscript.x:

```
\dontinclude ldscript.x
\skip .text :
\until   }  > text
```

All commands must write their answer to term_reply and it should not be longer than TERM_BUFSIZE. If nothing is written to term_reply automatically an "OK" is generated. The only exception to that is when the bit SERIALONLY in the flag field is set. That means that the terminal command uses the serial functions directly (not writing its answer to term_reply) and can't be called over radio.

```
bool Messaging_on();
```

Function: Enables the Messaging (started by system)

Parameter: None

Return value: <code>True</code> always.

```
void Messaging_serialHandler();
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

```
bool Messaging_requestHandler();
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

```
bool Messaging_answerHandler();
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

```
bool Messaging_requestDataHandler(UINT8* data);
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

3.6 ScatterWeb.Net

\ScatterWeb 2.x\System\src\ScatterWeb.Net.h

```
#ifndef ScatterWeb_Net
#define ScatterWeb_Net
  #include "ScatterWeb.System.h"
  #define BROADCAST             (0xFFFF)
  #define UNKNOWN               (0x0000)
  #define ACK_PACKET            (0x00)
  #define SYNC_PACKET           (0x01)
  #define PING_PACKET           (0x02)
  #define PONG_PACKET           (0x03)
  #define MESSAGING_REQ_PACKET  (0x04)
  #define MESSAGING_ANS_PACKET  (0x05)
  #define SCAN_PACKET           (0x06)
  #define SCAN_REPLY_PACKET     (0x07)
  #define SENSOR_PACKET         (0x08)
  #define FLASH_HEADER          (0x11)
  #define FLASH_HEADER_REPLY    (0x12)
  #define FLASH_DATA            (0x14)
  #define FLASH_REQ             (0x15)
  #define PICTURE_REQ_PACKET    (0x16)
  #define PICTURE_ANS_PACKET    (0x17)
  #define ROUTING_INFO          (0x20)
  #define ROUTING_REQUEST       (0x22)
  #define ROUTING_ACCEPT        (0x23)
  #define ROUTING_DENY          (0x24)
  #define ROUTING_NOCHILD       (0x25)
  #define ROUTING_ROOTPACKET    (0x26)
  #define ROUTING_TREEPACKET    (0x27)
  #define RSA_KEYREQUEST        (0x28)
  #define RSA_KEYREPLY          (0x29)
  #define DHCP_PACKET           (0x30)
  #define IS_RADIO_RECEIVING (cdCounter)
  #define IS_RADIO_SENDING   ((P5OUT & 0xC0)==0x40)
  typedef struct {
      UINT16 to;
      UINT16 from;
```

```
      UINT8 type;
      UINT8 num;
      UINT8* header;
      UINT16 header_length;
      UINT8* data;
      UINT16 data_length;
  } packet_t;
  extern volatile packet_t rxPacket;
  extern packet_t sentPacket;
  extern volatile UINT8 txRetries;
  extern volatile UINT8 cdCounter;
  extern volatile UINT8 txState;
  bool Net_init();
  bool Net_on();
  bool Net_off();
  bool Net_setTxPower(UINT8 value);
  bool Net_send(packet_t* packet, fp_char_t callback);
  bool Net_rxHandler();
  bool Net_txHandler();
  char Net_esend(packet_t* packet, fp_char_t callback);
#endif
```

The ScatterWeb.Net implements a network service that enables you to develop applications that use network resources without worrying about the specific details of the individual protocol.

This file contains following functionality for radio:

- Setting of transmit power (in 100 steps).
- Interrupt driven rx & tx radio MAC logic (sending of packets with CSMA and random backoff, CRC-16 checksums, acknowledgement with automatic retransmission).

General

Radio software supports acknowledgements, so it is important to know that all packet types which are no broadcast will get acknowledged by radio software and get repeated several times if needed. The radio software uses the num field for acknowledged packets to recognize doubles. packet_t is a struct containing

a packet header fields and pointers to packet data and is used for sending & receiving. As a packet may be often constructed out of a header portion and a data portion, packet_t supports two data pointers to get passed in for sending, so these portions don't need to be copied together. When receiving however, data pointer contains header and data consecutively and header and header_length are null.

How to receive packets

To receive packets of a specific type one must define a handler function and add it to Net_txHandler for firmware handlers or to the C_RADIO app callback function. When the handler is then called, the function can access the received packet in rxPacket.

How to send packets

For sending packets a packet_t must be initialized:

- to must contain the destination id of receiver or broadcast address.
- type must contain the packet type.
- header/data must be set to NULL or to the data that should get transported. If set, header_length/data_length should contain the length of the data.
- num can be set to transport a byte for not acknowledged packets, otherwise it will get overwritten.
- from is always overwritten with the id of this device.

Such a packet can then be queued into tx ring buffer with Net_send and a pointer to initialized packet_t. Additionally these two functions accept a callback pointer to functions which accept an UINT8. If set, this callback is called when the packet is removed from the tx ring buffer:

- For unacknowledged packets this is after sending the packet.
- For acknowledged packets this is after successfully receiving an ACK for this packet (callback argument is set to 1) or when all retries are made without success (callback argument is set to 0).

The callback function can check the variable txRetries to see how much retries it took (always 0 for unacknowledged packets).

```
bool Net_init();
```

Function: Initializes the radio

Parameter: None

Return value: <code>True</code> always;

```
bool Net_on();
```

Function: Enables the radio

Parameter: None

Return value: <code>True</code> always;

```
bool Net_off();
```

Function: Disables the radio

Parameter: None

Return value: <code>True</code> always;

```
bool Net_setTxPower(UINT8 value);
```

Function: Sets the transceiver power

Parameter: value - tx power to set

Return value: <code>True</code> if value are between 0 and 100;
<code>False</code> otherwise.

```
bool Net_send(packet_t* packet, fp_char_t callback);
```

Function: Sends a packet over radio

Parameter: packet - packet to send
callback - will call after sending (without: use NULL)

Return value: <code>True</code> if packet is successfully buffered;
<code>False</code> otherwise.

```
bool Net_rxHandler();
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

```
bool Net_txHandler();
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

```
char Net_esend(packet_t* packet, fp_char_t callback);
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

3.7 ScatterWeb.String

```
\ScatterWeb 2.x\System\src\ScatterWeb.String.h
#ifndef ScatterWeb_String
#define ScatterWeb_String
  int String_writeUInt(fp_char_t writer, UINT16 number,
      UINT16 length);
  int String_writeULongInt(fp_char_t writer, UINT32 number,
      UINT16 length);
  bool String_fromByteToHex(UINT8 b, UINT8* cs);
  UINT8 String_fromHexToByte(const UINT8* cs);
  bool String_writeTemperature(fp_char_t writer, temp_t temp);
  bool String_abstractWrite(fp_char_t writer, const char *fmt,
      va_list argp);
  bool String_write(UINT8* dest, const char *fmt, ...);
  UINT16 String_parseInt(const UINT8* c, UINT8** ptr);
  UINT32 String_parseLongInt(const UINT8* c, UINT8** ptr);
#endif
```

The ScatterWeb.String represents text; that is, a series of Unicode characters.

```
int String_writeUInt(fp_char_t writer, UINT16 number, UINT16 length);
```

Function: Converts int to String

Parameter: writer - function to write

number - number to write

length - length to write

Return value: position in output out[pos]

```
int String_writeULongInt(fp_char_t writer, UINT32 number, UINT16 length);
```

Function: Converts long int to String

Parameter: writer - function to write

number - number to write

length - length to write

Return value: position in output out[pos]

```
bool String_fromByteToHex(UINT8 b, UINT8* cs);
```

Function: Converts the byte *b into the string cs[0] cs[1].

Parameter: b - byte

cs - string

Return value: <code>True</code> always.

```
UINT8 String_fromHexToByte(const UINT8* cs);
```

Function: Converts the string at cs[0] cs[1] into a byte at *b.

Parameter: cs – string

Return value: value to convert into

```
bool String_writeTemperature(fp_char_t writer, temp_t temp);
```

Function: Writes a temperature according to the format described in System_getTemperature ([+-]xxx.x).

Parameter: writer - function to write

temp - temperature

Return value: <code>True</code> always.

```
bool String_abstractWrite(fp_char_t writer, const char *fmt, va_list argp);
```

Function: Simple printf implementation for RS232 output.

Supports - amongst others:

- %c: Prints a character.

- %i: Prints an UINT16eger in decimal format.

- %l: Prints an UINT32eger in decimal format

- %b: Prints a byte in hex format.

- %x: Prints an int in hex format.

Parameter: writer - function to write

fmt - function

argp - list of arguments

Return value: <code>True</code> always.

```
bool String_write(UINT8* dest, const char *fmt, ...);
```

Function: Writes

Parameter: dest - dest

fmt - function

... - list of parameters

Return value: <code>True</code> always.

```
UINT16 String_parseInt(const UINT8* c, UINT8** ptr);
```

Function: Parses int

Parameter: c – c

ptr - ptr

Return value: parsed int

```
UINT32 String_parseLongInt(const UINT8* c, UINT8** ptr);
```

Function: Parses long int

Parameter: c - c

ptr - ptr

Return value: parsed long int

3.8 ScatterWeb.Synchronisation

```
\ScatterWeb 2.x\System\src\ScatterWeb.Synchronisation.h
#ifndef ScatterWeb_Synchronisation
#define ScatterWeb_Synchronisation
  #define ROOT_TIMEOUT          5
  #define FRAME_LENGTH          3
  #define INIT_LENGTH           4
  volatile struct {
      UINT8 seqNum;
      UINT16 masterRootId;
      UINT8 syncPeriods;
  } SyncStruct;
  bool Synchronisation_init();
  bool Synchronisation_isRoot();
  bool Synchronisation_registerSyncDone(void(*fp_t)());
  bool Synchronisation_doSync();
#endif
```

The ScatterWeb.Synchronisation represents the synchronisation.

```
bool Synchronisation_init();
```

Function: Initializes the synchronisation (not started by system)

Parameter: None

Return value: <code>True</code> always.

```
bool Synchronisation_isRoot();
```

Function: Checks if node is currently the root

Parameter: None

Return value: <code>True</code> if node is root;

<code>False</code> otherwise.

```
bool Synchronisation_registerSyncDone(void(*fp_t)());
```

Function: Registers a function which is called if the sync ends

Parameter: () - function to call

Return value: <code>True</code> always.

```
bool Synchronisation_doSync();
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

3.9 ScatterWeb.System

\ScatterWeb 2.x\System\src\ScatterWeb.System.h

```
#ifndef ScatterWeb_System
#define ScatterWeb_System
  #define WAKEUPLPM1(irqname, bit)  do {     \
      __asm__ __volatile__ ("bic %0, .L__FrameOffset_"
      #irqname "(r1)": : "i" ((uint16_t)LPM1_bits)); \
      runModule |= bit; \
      }while(0)
  #if !(defined(ESB) || defined(eGate) || defined(ECR))
      #error "No device specified: ECR, ESB, eGate"
  #endif
  #define TERM_BUFSIZE        (82)
  #define SERIAL_BUFSIZE      (82)
  #define RADIO_RXBUF_SIZE    (270)
  #define RADIO_TXBUF_SIZE    (400)
  #define MAX_TIMERS          (20)
  #define MAX_TASKS           (10)
  #define INFOMEM            __attribute__((section(".infomem")))
  #define INFOMEMNOBITS
      __attribute__((section(".infomemnobits")))
  #define   SET(x, y)     ((x) |= (y))
  #define   CLEAR(x, y)   ((x) &= (~y))
  #define MF_SCOS       (0x0001)
  #define MF_RADIO_RX   (0x0002)
  #define MF_RADIO_TX   (0x0004)
  #define MF_TIMER      (0x0008)
  #define MF_SERIAL_RX  (0x0010)
  #define MF_SENSORS    (0x0020)
  #define MF_RC5        (0x0080)
  #define STARTUP_POR       (0)
  #define STARTUP_SWRESET   (1)
  #define STARTUP_REPROGRAM (2)
  #define STARTUP_PANIC     (3)
  #define STARTUP_WATCHDOG  (4)
  #define STARTUP_KEYV      (5)
  #define STARTUP_UNKNOWN   (6)
```

```
#define WDS_RUNNING       (0xAB01)
#define WDS_SWRESET       (0xAB02)
#define WDS_REPROGRAM     (0xAB03)
#define WDS_PANIC         (0xAB04)
#define INIT_FCS  0xffff
#define C_SERIAL              1
#define C_RADIO               2
#define C_SENSOR              3
#define NUMBER_CALLBACKS      4
#define MICIFG    (0x01)
#define MICIE     (0x02)
#define MICVOLTAGE        (ADC12MEM2)
#define EXTERNVOLTAGE     (ADC12MEM3)
#define BATTERYVOLTAGE    (ADC12MEM4)
#define RXPVOLTAGE        (ADC12MEM5)
#define BATTERYVOLTAGE    (ADC12MEM4)
enum {
    True = 1,
    False = 0,
};
typedef char bool;
typedef union { unsigned int u; signed int s; } temp_t;
typedef unsigned char UINT8;
typedef unsigned int UINT16;
typedef unsigned long UINT32;
typedef void(*fp_t)();
typedef void(*fp_string_t)(UINT8*);
typedef void(*fp_char_t)(UINT8);
typedef void(*fp_int_t)(UINT16);
typedef void(*fp_vp)(void*);
extern fp_vp callbacks[];
extern volatile UINT16 runModule;
extern volatile UINT16 rxpTemp;
extern volatile UINT16 rxpValue;
#if defined(ESB)
    extern volatile UINT8 MIC;
#endif
```

```
bool System_registerCallback(UINT8 type, void(*fp_t)());
temp_t System_getTemperature();
bool System_setDCO();
bool System_startWatchdog();
bool System_stopWatchdog();
bool System_reset();
const UINT8* System_resetReason();
bool System_panic(const char *fmt, ...);
UINT8* System_panicReason(UINT16 n);
bool System_panicClear();
bool System_wait(UINT32 w);
bool System_waitA(UINT16 i);
bool System_powerOn();
bool System_powerOff();
UINT16 System_reprogram();
bool System_startConversion();
#include <msp430x14x.h>
#include <io.h>
#include <signal.h>
#include <stdlib.h>
#include <stdarg.h>
#if defined(ECR)
    #include "../lib/ecr/programming.h"
    #include "../lib/ecr/flasher.h"
#elif defined(ESB)
    #include "../lib/esb/programming.h"
    #include "../lib/esb/flasher.h"
#elif defined(eGate)
    #include "../lib/egate/programming.h"
    #include "../lib/egate/flasher.h"
#endif
#include "ScatterWeb.Configuration.h"
#include "ScatterWeb.Data.h"
#include "ScatterWeb.Timers.h"
#include "ScatterWeb.Time.h"
#include "ScatterWeb.IO.h"
#include "ScatterWeb.Comm.h"
```

```
  #include "ScatterWeb.Net.h"
  #include "ScatterWeb.Messaging.h"
  #include "ScatterWeb.Threading.h"
  #include "ScatterWeb.String.h"
  #include "ScatterWeb.Synchronisation.h"
#endif
```

The ScatterWeb.System contains fundamental functions that define commonly-used value and reference data types, events and event handlers, attributes, and processing exceptions.

ADC: Starting, enabling, disabling and ISR for ADU.

The main function of the ADU is to sample the unfiltered radio receive output and provide a "carrier detect" (see interrupt routine ADC12ISR and rxReceiveLimit in Configuration). Look for defines in ScatterWeb.System.h to access other ADC readings.

CLOCK: Methods for interfacing DS1629 (RTC with temperature) and LM71 (temperature sensor). For both devices the function getTemperature is implemented. It returns the temperature in fixed point [9.7] 2s complement format! DS1629 - initClock should be called at startup to check for the correct setting in the status register of the RTC. Most functions of the clock have been removed due to high current usage while reading the clock. Furthermore a software RTC has been implemented with a much finer resolution (see ScatterWeb.Time.c). The RTC is now only used as an well calibrated temperature sensor and only these functions remain here (for complete clock interfacing code look into attic directory). cl_start(), cl_stop(), cl_writeOnBus() and cl_readFromBus are the basic functions for interfacing the RTC (I2C like bus).

Ports (ESB/EYE): clockSDA P50, clockSCL P51, clockAlarm P15

Note: The sticks have no RTC and the ECR has the LM71 temperature sensor which is also realized in this file.

CRC: This file offers CRC calculation.

DCO: Initializing & Controlling the DCO (Digitally Controlled Oscillator)

If FF_DCOCHECKER in config_t.firmwareFlags is set Timers_init will add a timer every 100 ms for checkDCO and enable Timer_B1 interrupt. The interrupt continually measures the ACLK with the DCO (like in System_setDCO) and writes the result into dcoDiff. checkDCO takes samples every 100 ms of dcoDiff and adjusts the DCO if needed. As the DCO is temperature-sensitive and both serial and radio communication depend on the DCO calibrating the DCO continuously is recommended. Serial communication stops working at a temperature difference of ~10°C. A more low power option might be to not use checkDCO and just call System_setDCO in long intervals (a minute or even longer).

WATCHDOG: Hardware & Software watchdog, reset reason, stack check and panics. This module contains two macros to control the hardware watchdog. Furthermore it supports determining the reset source, a simple stack checker to avoid stack overflows and a panic function.

Hardware & Software Watchdog

The macro System_startWatchdog() allows starting or resetting both watchdogs, System_stopWatchdog() stops it. These macros are mostly for firmware internal use. In the perfect case noone should call System_stopWatchdog() and the only place to call System_startWatchdog() repeatedly would be the main loop. However some software parts need a long time or must run exclusively (then also disabling the interrupts together with System_stopWatchdog()). Timer_A1 interrupt was used to implement a software watchdog with a timer interrupt running together with the built in hardware watchdog, because an interrupt offers the possibility to recover the address where the watchdog timeout occurred. This address gets written in a panic message, when Timer_A1 Interrupt fires (what means watchdog timeout). Putting the hardware watchdog into interrupt mode (what is possible with the MSP430) is not a good idea, because then it can't recover the MCU in a case, where it is not running at all (for example MSP430s known startup problems with a slow or noisy voltage rise which lead to such a situation).

Reset source

The function wd_init() runs at the very beginning of main just after initPort(). It checks some registers to see where the reset came from and then sets wd_startup accordingly.

Technical details of wd_init():

The MSP internally has two reset signals (slau049.pdf, Chapter 3):

- POR (power-on reset): This is a device reset. Set by Power-Up or a low RST line when configured in reset mode (standard).
- PUC (power-up clear); A PUC follows every POR. But it can occur also without because of watchdog timer expiry or flash control register key violation.

The SFRs are initialized on resets and some bits get only set or reset, when a POR occurred, not on a PUC only (these in braces, see slau049.pdf, page 3-4). This feature is used by wdt_init with the register TACTL to detect a POR since it will only get reset (complete zero) if a POR occurred. If a PUC only occurred it was a warm start. The function looks further whether it was the WDT, Flash key violation or an unknown source. If it was a Flash key violation it is checked with var wd_state whether it was wanted by software (System_reset() with wd_state == WDS_SWRESET or System_panic() with wd_state == WDS_PANIC) or a real key violation.

Stack checking

wd_stackCheck is a small function which once called by main runs once every second with a timer. It checks 8 bytes on top of the data segment (behind __noinit_end provided by the linker script) for corruption. The reset_vector in main() fills the memory from __noinit_end - 0x09FF with 0xABCD, so the procedure simply checks the four ints from __noinit_end for the value 0xABCD. If they are not there, the stack must have gone that low and possibly lower. The procedure will panic then.

Panic

System_panic is a function to call when some bad condition was detected (for example low stack, full timers). System_panic writes a small info msg into second info memory segment (0x1080-0x10FF) and then resets the controller. Multiple panic messages can be written until the segment is full. One could go further and implement a complete memory dump into flash, what would give the possibility to examine the complete system state later for debugging.

LPM: Power saving

The sensor board features low power modes to reduce power consumption. This increases battery-powered lifetime up to years and makes it even possible to run the sensor board solely with a gold cap / solar cell combo.

Following units can be switched off to reduce power consumption:

- Unit - Power consumption - Corresponding function – Comments
- ScatterWeb.Net - 4,7 - 5,2mA - Net_off(), Net_on()
- ScatterWeb.Data - 2,9mA - System_powerOff(), System_powerOn()

The MSP430 itself goes to sleep when nothing more has to be done (see super loop in main). Power consumption with everything disabled (Radio, Sensor) goes below 1mA. This file contains special definitions & configuration options for the firmware and includes all other headers. The firmware provides abstract functions to interface and use the hardware, contains the main execution loop + interrupts and provides some OS-like concepts. The firmware supports all ScatterWeb/MSP430 devices: ESB, EYE, eGate, ECR

The first reprogramming concept which produced the firmware/application separation was abandoned for two main reasons:

- It relied on a stable almost never changing firmware. At the moment this is absolutely wrong and it’s questionable if it will ever be.
- It relied on the compiler/linker to produce always the same assembler output for the firmware when it gets always the same sources/object files. This was only partially right (it depended on too many factors: compiler version, compiler flags, even the machine the compiler is running on...) and could be wrong under other or future conditions.

Perhaps one needs to write his own compiler/linker (or at least modify an existing one) to really separate these two software parts on a MCU cleanly.

```
bool System_registerCallback(UINT8 type, void(*fp_t)());
```

Function: Registers callback

Parameter: type - type of callback

() - function to call

Return value: <code>True</code> always.

```
temp_t System_getTemperature();
```

Function: Returns temperature

Parameter: None

Return value: current temperature.

```
bool System_setDCO();
```

Function: Sets DCO

Parameter: None

Return value: <code>True</code> always.

```
bool System_startWatchdog();
```

Function: Starts watchdog

Parameter: None

Return value: <code>True</code> always.

```
bool System_stopWatchdog();
```

Function: Stops watchdog

Parameter: None

Return value: <code>True</code> always.

```
bool System_reset();
```

Function: Resets System

Parameter: None

Return value: <code>True</code> always.

```
const UINT8* System_resetReason();
```

Function: Checks the reset

Parameter: None

Return value: pointer of reset message

```
bool System_panic(const char *fmt, ...);
```

Function: Sets panic flag

Parameter: fmt - panic to set

... - parameters to set

Return value: <code>True</code> always.

```
UINT8* System_panicReason(UINT16 n);
```

Function: Checks panic flag

Parameter: n - panicReason[n]

Return value: pointer of the panic messages

```
bool System_panicClear();
```

Function: Clears the panic flags

Parameter: None

Return value: <code>True</code> always.

```
bool System_wait(UINT32 w);
```

Function: Waits - A simple looping waiting function. Rough estimate at 2,4576 MHz: w=1

=> 18us, w=10 => 62us, w=100 => 500us w=400 => 4ms.

This method has two big disadvantages: it blocks and it's not accurate, timers are better.

Parameter: w - ticks to wait

Return value: <code>True</code> always.

```
bool System_waitA(UINT16 i);
```

Function: Waits which is more precise than wait because it uses TimerA to produce its interval, also blocking.

Parameter: i - ticks to wait

Return value: <code>True</code> always.

```
bool System_powerOn();
```

Function: Enables the sensor and serial power

Parameter: None

Return value: <code>True</code> always.

```
bool System_powerOff();
```

Function: Disables the sensor and serial power

Parameter: None

Return value: <code>True</code> always.

```
UINT16 System_reprogram();
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

```
bool System_startConversion();
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

3.10 ScatterWeb.Threading

\ScatterWeb 2.x\System\src\ScatterWeb.Threading.h

```
#ifndef ScatterWeb_Threading
#define ScatterWeb_Threading
  extern volatile UINT16 Threading_currentThread;
  bool Threading_init();
  bool Threading_add(void* address);
  bool Threading_doEvents();
  bool Threading_sleep(UINT16 ticks);
  bool Threading_wait(UINT8* adr, UINT8 bitmask);
  bool Threading_eventHandler();
  bool Threading_packetHandler();
  bool Threading_sentPacketHandler(UINT16 p, UINT16 success);
  bool Threading_recv(UINT16 sender, UINT16 type, UINT16 timeout);
  bool Threading_recvp(UINT16 sender, UINT16 type, UINT16 timeout);
  bool Threading_send (UINT16 to, UINT16 type, UINT8* h, UINT16 hl,
      UINT8* d, UINT16 dl);
  bool Threading_esend(UINT16 to, UINT16 type, UINT8*h, UINT16 hl,
      UINT16 d, UINT16 dl);
#endif
```

The ScatterWeb.Threading provides functions that enable multithreaded programming.

ScatterOS

This file implements a simple cooperative scheduling mechanism which allows to run task functions with OS like blocking calls (which in fact do not block the processor but return control to the system and get later resumed).

The OS primitives at the moment are:

- Threading_doEvents - Simply returns control to the system. As this is a cooperative scheduler long tasks or tasks which make no other Threading_ calls must interrupt themselves with Threading_doEvents.
- Threading_sleep - Makes the task wait a specified amount of system ticks (may get longer if system is busy).
- Threading_wait - Makes the task wait for a flag set.

- Threading_recv / Threading_recvp - Makes the task wait for a packet of a given type (and a given sender if wanted). A timeout can be set and Threading_recvp works in promiscuous mode.
- Threading_send / Threading_esend - A synchronous send, task will continue after the packet was sent or lost (removed from radio rx ring buffer). Threading_esend is for sending data from EEPROMm.

These are not many but suit the needs at the moment.

Constraints

The goal was to write a task switching mechanism with minimal memory requirements. Each preemptive OS requires and most cooperative OS use one stack per task (Exceptions seen so far are PeerOS in the EYES Project, which preempts only lower priority tasks and lets them reside at the stack while executing a higher priority task, and Salvo, which seems to implement a very similar approach). To have a stack for each task increases memory requirements a lot, because the size of the stack for a task is unknown and must be generously set. The optimum would be the maximum stack depth of the task call tree. A compiler could easily calculate this if recursion and function pointers are not used, but i do not know if any compiler supports this feature. The second bad is that most times a task won't use its maximum stack depth. In contrast to theses approaches this mechanism uses no memory (only some static allocated memory for task table and a little bit of stack space like in every other function is needed). This puts some limits onto the task functions to make this possible. Task functions can't and should never allocate stack space. In fact you can allocate stack space and the scheduler will handle it properly (that was needed for calls with long argument list which get pushed onto the stack), but after a Threading_ call the stack content will always be undefined. That means that all state must be held in vars declared globally. Additionally they should be declared volatile so the compiler won't do any optimization on them (hold them in registers, also register content is undefined after a Threading_ call). Secondly it means that blocking Threading_ functions are only allowed to call within your top-level task function, not in functions called from your top-level task function! The reason for that is again the stack, which is undefined after a Threading_ call and so will thrash the return address for Threading_ calls anywhere outside from your top-level task function.

How it works

A task is initialized with Threading_add, which gets a pointer to the task function. If a task can run (like a newly added task) sooner or later scos_call

with the id of the task in the task table and a value is called. scos_call saves the current stack pointer, sets currentTask and calls the next-to-continue address of the task like a function with an int argument. Then the task runs until it calls a Threading_ function. These functions save the return address of the task on the stack as the next-to-continue address in the task table, change the state of the task and call scos_exit. scos_exit now just restores the stack pointer to the value scos_call saved and does a return, which now is like the return of scos_call and so the system is again in a clean state.

Related

The System Stack Pointer (SP)

The system stack pointer must always be aligned to even addresses because the stack is accessed with word data during an interrupt request service. The system SP is used by the CPU to store the return addresses of subroutine calls and interrupts. It uses a pre-decrement, post-increment scheme. The advantage of this scheme is that the item on the top of the stack is available. The SP can be used by the user software (PUSH and POP instructions), but the user should remember that the CPU also uses the SP. Figure 5–2 shows the system SP bits.

Call a subroutine:

CALL dst SP – 2 –> SP, PC+2 –> stack, dst –> PC

Return from subroutine:

RET MOV @SP+,PC

-fno-defer-pop

Always pop the arguments to each function call as soon as that function returns. For machines which must pop arguments after a function call, the compiler normally lets arguments accumulate on the stack for several function calls and pops them all at once. Perhaps a cleaner and more portable but also more memory consuming implementation would be possible with setjmp()/longjmp() macros.

Helper for scos_call

Had to be put into an extra function because of following problem:

The following instruction ("mov & savedSP, r1"::) is not really needed because if execution returns here, the stack pointer should be what we saved before. The important thing is to tell the compiler, that the usually caller preserved registers (r6-r11) may have changed! The problem is the indexing into the Tasks table. If following line is omitted the assembler output is:

```
scos_prolog(value, Tasks[currentTask].address, Tasks[currentTask].stackSize);
7154:  1e 42 50 06  mov    &0x0650,r14 ;0x0650
7158:  3b 40 54 06  mov    #1620,      r11     ;#0x0654
...
718a:  b0 12 42 71  call   #28994              ;#0x7142
//__asm__ __volatile__("mov &savedSP, r1"::); // restore stack pointer
Tasks[currentTask].address = 0x0000;
718e:  1e 42 50 06  mov    &0x0650,r14 ;0x0650
...
71a0:  0f 5b        add    r11,    r15     ;
71a2:  8f 43 00 00  mov    #0,     0(r15) ;r3 As==00
Tasks[currentTask].state = T_DESTROYED;
...
71b8:  0f 5b        add    r11,    r15     ;
71ba:  8f 43 04 00  mov    #0,     4(r15) ;r3 As==00
```

That is bad. At the beginning the base address of Tasks is moved into r11 for reading out of the table for the scos_prolog call. r11 is later (after scos_prolog call) used to index into Tasks again, and the compiler can assume, that r11 did not change (according to normal calling conventions), but that may be wrong in this case. When the following instruction is used, the compiler omits the "add r11,r15" and addresses the table directly:

```
__asm__ __volatile__("mov &savedSP, r1"::); // restore stack pointer
718e:  11 42 4a 06  mov    &0x064a,r1   ;0x064a
Tasks[currentTask].address = 0x0000;
...
71a4:  8f 43 54 06    mov    #0,      1620(r15);r3 As==00
Tasks[currentTask].state = T_DESTROYED;
...
71ba:  8f 43 58 06    mov    #0,      1624(r15);r3 As==00
```

I don’t know why the compiler does that thing not always this way (it saves on instruction). I tried to force it by telling all registers get clobbered through this instruction:

```
__asm__ __volatile__("mov &savedSP, r1":: : "r15", "r14", "r13", "r12",
"r11", "r10", "r9", "r8", "r7", "r6");
restore stack pointer
```

But this produced the same behavior like the first, BUT instead of r11 being used it is now r5 which is even more worse. r5 is the frame pointer and strangely used by gcc. The compiler should never assume r5 is preserved over function calls, very strange why it does that here (even when r15 is appended to the list of clobbered registers). Anyway it works with the second. But that may change with -O flags or anything else, so best will be to put that into an extra function. Make sure this function does not get inline into scos_call again with -fno-inline for this file?!

```
bool Threading_init();
```

Function: Initializes the threading

Parameter: None

Return value: <code>True</code> always.

```
bool Threading_add(void* address);
```

Function: Adds thread

Parameter: address - address of task

Return value: <code>True</code> if successful;

<code>False</code> otherwise.

```
bool Threading_doEvents();
```

Function: Does events

Parameter: None

Return value: <code>True</code> always.

```
bool Threading_sleep(UINT16 ticks);
```

Function: Sleeps for ticks

Parameter: ticks - ticks to wait

Return value: <code>True</code> always.

```
bool Threading_wait(UINT8* adr, UINT8 bitmask);
```

Function: Waits until address == bitmask

Parameter: adr - address

bitmask - bitmask

Return value: <code>True</code> always.

```
bool Threading_eventHandler();
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

```
bool Threading_packetHandler();
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

```
bool Threading_sentPacketHandler(UINT16 p, UINT16 success);
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

```
bool Threading_recv(UINT16 sender, UINT16 type, UINT16 timeout);
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

```
bool Threading_recvp(UINT16 sender, UINT16 type, UINT16 timeout);
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

```
bool Threading_send
(UINT16 to, UINT16 type, UINT8* h, UINT16 hl, UINT8* d, UINT16 dl);
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

```
bool Threading_esend
(UINT16 to, UINT16 type, UINT8*h, UINT16 hl, UINT16 d, UINT16 dl);
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

3.11 ScatterWeb.Time

\ScatterWeb 2.x\System\src\ScatterWeb.Time.h

```
#ifndef ScatterWeb_Time
#define ScatterWeb_Time
  #include "ScatterWeb.System.h"
  #define CURRENT_TIME \
      ({ \
            extern volatile time_t currentTime; \
            time_t time;  \
            dint(); \
            _NOP(); \
            time = currentTime; \
            eint(); \
            time; \
      })
  #define CURRENT_TIME_SECS \
      ({ \
            extern volatile time_t currentTime; \
            UINT32 secs;  \
            dint(); \
            _NOP(); \
            secs = currentTime.secs; \
            eint(); \
            secs; \
      })
  typedef struct {
      UINT8 year;
      UINT8 month;
      UINT8 day;
      UINT8 hour;
      UINT8 min;
      UINT8 sec;
  } btime_t;
  typedef struct {
      UINT32 secs;
      UINT16 millis;
  } time_t;
```

```
  time_t* Time_getSystemTime(time_t* time);
  bool Time_setSystemTime(time_t* time);
  bool Time_convertSystemTime(const time_t* src, btime_t* dst);
  bool Time_convertTime(const btime_t* src, time_t* dst);
  bool Time_writeTime(fp_char_t writer, btime_t* time);
  bool Time_readTime(const UINT8* c, btime_t* time);
#endif
```

The ScatterWeb.Time represents an instant in time, typically expressed as a date and time of day. This file keeps the global time of this node in the global var currentTime. It contains methods for writing, reading and converting currentTime. To avoid concurrency problems accessing currentTime must be done with disabled interrupts or in interrupt routines only. This defines some macro for accessing Time_currentTime safely.

```
time_t* Time_getSystemTime(time_t* time);
```

Function: Read currentTime or safely with disabled interrupts. Easier (and also faster) to use is CURRENT_TIME:

time_t time = CURRENT_TIME; <-> time_t time; getCurrentTime(&time);

Parameter: time - current time struct to store system time

Return value: pointer of time

```
bool Time_setSystemTime(time_t* time);
```

Function: Write currentTime or safely with disabled interrupts.

Parameter: time - current time to set

Return value: <code>True</code> always.

```
bool Time_convertSystemTime(const time_t* src, btime_t* dst);
```

Function: Converts time to broken down time

Parameter: src - input current time

dst - output btime

Return value: <code>True</code> always.

```
bool Time_convertTime(const btime_t* src, time_t* dst);
```

Function: Converts broken down time to time

Parameter: src - input time

dst - output current time

Return value: <code>True</code> always.

```
bool Time_writeTime(fp_char_t writer, btime_t* time);
```

Function: Writes broken down time as a string in the form yyyy-mm-dd hh:mm:ss

Parameter: writer - function to write

time - time to write

Return value: <code>True</code> always.

```
bool Time_readTime(const UINT8* c, btime_t* time);
```

Function: Reads broken down time as a string.

The format is the same as in Time_writeTime, but the year must be written without 2000. The number of digits is not fixed like in Time_writeTime, so it is ok to write 03-09-07 08:31:02 or 3-9-7 8:31:2.

Parameter: c - array to store time

time - time to read

Return value: <code>True</code> always.

3.12 ScatterWeb.Timers

```
\ScatterWeb 2.x\System\src\ScatterWeb.Timers.h
#ifndef ScatterWeb_Timers
#define ScatterWeb_Timers
  #include "ScatterWeb.System.h"
  typedef void(*fp_timer)(UINT16);
  bool Timers_init();
  bool Timers_add(UINT16 ticks, fp_timer fp, UINT16 data);
  bool Timers_reset(UINT16 t, fp_timer fp, UINT16 data);
  bool Timers_remove(fp_timer fp, UINT16 data);
  bool Timers_eventHandler();
#endif
```

The ScatterWeb.Timers provides the Timer component, which allows you to raise an event on a specified interval. The Timer component is a hardware-based timer, which allows you to specify a recurring interval at which the Elapsed event is raised in your application. You can then handle this event to provide regular processing.

Software timers

With theses function you can implement delays asynchronously. Just give a time and a pointer to a function which should get called when the time has elapsed. The timer entries are kept in a fixed size array (MAX_TIMERS, timers, numberTimers). The entry at position 0 will always contain the next timer to expire. The ticks in the timer entries are not decreased with every system tick but first accumulated into _ticks until one of two things happen:

- _ticks becomes greater than timers[0].ticks, what means that at least timers[0] has elapsed (if no timer is running timers[0].ticks is set to 0xFFFF, so this will never happen then). The interrupt routine sets callTimer to 1 and Timers_eventHandler will execute. It calls _consolidate and all elapsed timers (where ticks==0).
- - An overflow when adding a new timer is detected. For example a timer with 50000 ticks was added. _ticks has run up to 30000 and then a new timer with 40000 ticks comes in. To get the correct offset for the timer it has to be added internally with 30000+40000=70000 ticks, but that is greater than maximum integer value 65535. _consolidate is called which decreases first timer to 20000, _ticks to 0, the second timer is then added with 40000 ticks.

_consolidate reads _ticks and subtracts the value from all timers[i].ticks (or sets them to 0 if they are already smaller) and _ticks itself. This is a safe way to synchronize with the interrupt and better than setting _ticks to 0, because if _ticks is just increased by the interrupt in between read and write the single tick will not get lost.

```
bool Timers_init();
```

Function: Initialization of DCO, TimerA, TimerB and software timer table.

This method first calls SetDCO and initializes variables for timers. Timer_A is initialized to run from the divided 32,768 Hz Crystal at 4096 Hz. Timer_B is initialized to run from the self-regulated DCO at 4,505600 MHz.

Timer_A0 is used to generate an interrupt every 4 ticks once a 1024/second near to a millisecond.) Timer_A1(-3) is used by watchdog.c to implement a software watchdog. Timer_B0 is used by recir.c to capture RC5 signals every 890 us. Timer_B1(-6) is used to measure the DCO continously with TB6.

Parameter: None

Return value: <code>True</code> always.

```
bool Timers_add(UINT16 ticks, fp_timer fp, UINT16 data);
```

Function: Strictly adds a timer, also if it exists already. If ticks are passed, the given functions is called.

Parameter: ticks - ticks for elapse

fp - function to call if expired

data - parameter to call function (without: use 0xFFFF)

Return value: <code>True</code> if successful;

<code>False</code> otherwise.

```
bool Timers_reset(UINT16 t, fp_timer fp, UINT16 data);
```

Function: Adds or (if it already exists) resets a timer.

Parameter: ticks - ticks for elapse

fp - function to call if expired

data - parameter to call function (without: use 0xFFFF)

Return value: <code>True</code> if successful;

<code>False</code> otherwise.

```
bool Timers_remove(fp_timer fp, UINT16 data);
```

Function: Removes timer if data is matching

Parameter: fp - function to call if expired

data - parameter to call function (without: use 0xFFFF)

Return value: <code>True</code> if successful;

<code>False</code> otherwise.

```
bool Timers_eventHandler();
```

Function: This member supports the ScatterWeb infrastructure and is not intended to be used directly from your code.

Parameter: -

Return value: -

4 Usage

4.1 The [EMPTY] application

The [EMPTY] application presents the body to develop your own applications.

ScatterWeb.Process

The ScatterWeb.Process module enables you to initialize and start your application:

```
\ScatterWeb 2.x\Applications\<application>\<platform>\
  ScatterWeb.Process.c
```

Special commands of ScatterWeb.Process:

- app - read the name of the application

You are able to include all needed files like ScatterWeb.Event.h:

```
#include "ScatterWeb.Event.h"
```

You are in a position to include the core of the ScatterWeb.API:

```
#include "../../../../System/src/ScatterWeb.System.h"
```

The Process_interceptRadioHandler() handles all packets which are addressed to other nodes:

```
void Process_interceptRadioHandler() { }
```

The Process_radioHandler() handles all packets:

```
void Process_radioHandler() {
  if ( !(rxPacket.to == BROADCAST
      || rxPacket.to == Configuration.id) ) {
    Process_interceptRadioHandler();
  }
  else {
    switch(rxPacket.type){
      case ACK_PACKET: break;
      case MESSAGING_REQ_PACKET: Messaging_requestHandler(); break;
      case MESSAGING_ANS_PACKET: Messaging_answerHandler(); break;
      case PING_PACKET: {...} break;
      case PONG_PACKET: {...} break;
      default: break;
    }
  }
}
```

The COMMAND(app, 0) approves other nodes to check which application on this node is running:

```
COMMAND(app, 0) {
  String_write(term_reply, "[EMPTY]");
}
```

First of all the Process_init() will be called by the System when the complete core is initialized:

```
void Process_init(){
  System_registerCallback(C_RADIO, Process_radioHandler);
  Event_init();
  Comm_log(LOW, "| Application %s initialized\r\n\r\n",
      imageData.versionName);
}
```

This is the Software header (see programming.h for description). Theses variables are defined by the linker script; they are needed in the software header:

```
extern int __image_start;
extern int __image_end;
extern UINT16 prog_reprogram();
__attribute__((section(".imagedata"))) const imageData_t imageData = {
    (UINT16)&__image_start, (UINT16)&__image_end,
    x,
    (UINT16)prog_reprogram,
    "ESB: V2.xx",
    __DATE__ " " __TIME__
};
#endif
```

ScatterWeb.Event

The ScatterWeb.Event module presents methods for handling and forwarding sensor data events.

Special commands of ScatterWeb.Event:

- dsr - set flags to print no sensor data to none
- esr - set flags to print sensor data to radio
- raf - read announce flags
- rsm - read sensor mask

- saf - set announce flags
    - Valid values are:
        - 01 = AF_SERIAL
        - 02 = AF_RADIO
        - or a combination of this values

- ssm - set sensor mask to x
    - Valid values are:
        - 01 = SENSOR_MICROPHONE
        - 02 = SENSOR_TEMPERATURE
        - 04 = SENSOR_RC5
        - 08 = SENSOR_MOVEMENT
        - 10 = SENSOR_VIBRATION
        - 40 = SENSOR_VOLTAGE
        - 80 = SENSOR_BUTTON
        - or a combination of this values

```
\ScatterWeb 2.x\Applications\<application>\<platform>\
  ScatterWeb.Event.h
#ifndef ScatterWeb_Event
#define ScatterWeb_Event
  #include "../../../../System/src/ScatterWeb.System.h"
  #define AF_SERIAL    (0x01)
  #define AF_RADIO     (0x02)
  typedef struct {
      UINT8 announceFlags;
      UINT8 sensorMask;
  } appconfig_t;
  bool Event_init();
#endif
```

Processes events according to sensorMask and announceFlags:

appconfig_t.sensorMask contains what sensors will be processed (commands "rsm"/"ssm"):

- 0x10 SENSOR_VIBRATION - Vibration sensor
- 0x08 SENSOR_MOVEMENT - PIR sensor
- 0x80 SENSOR_BUTTON - Button
- 0x01 SENSOR_MICROPHONE - Microphone
- 0x02 SENSOR_TEMPERATURE - Temperature
- 0x04 SENSOR_RC5 - RC5 Receiving
- 0x40 SENSOR_VOLTAGE - Battery Voltage

appconfig_t.announceFlags contains what will be done with sensor events (commands "raf"/"saf"):

- 0x01 AF_SERIAL - Prints events to serial port
- 0x02 AF_RADIO - Broadcasts events in a SENSOR_PACKET.

So to get all sensors reported over serial link and radio do:

<code>

ssm FF

saf 03

</code>

```
bool Event_init();
```

Function: Initializes the event handling

Parameter: None

Return value: <code>True</code> always.

4.2 How to install

An adapted GNU compiler for the MSP (mspgcc) is used for software development for the MSP430. Additional MSP430FreeTools from IAR can flash the code onto the board. Furthermore, the freely available editor PSPad enables project management, compilation and flashing in a few simple steps.

scatterweb_package directory tree:

[Installers] – Installers for IARTools, GNU compiler and PSPad, only the installer for the IARTools is needed during the following installation

[msp430] – Already prepared directory for the installation, simply copy to C:\

[Sources] – Source code directory

1. Copy the directory MSP430 to C:\MSP430
2. Run the installer for the IARTools, install to C:\MSP430\IAR Systems
3. Add 3 paths:

   C:\MSP430\IAR Systems

   C:\MSP430\IAR Systems\430\bin

   C:\MSP430\mspgcc\bin

   or append the following to the PATH variable:

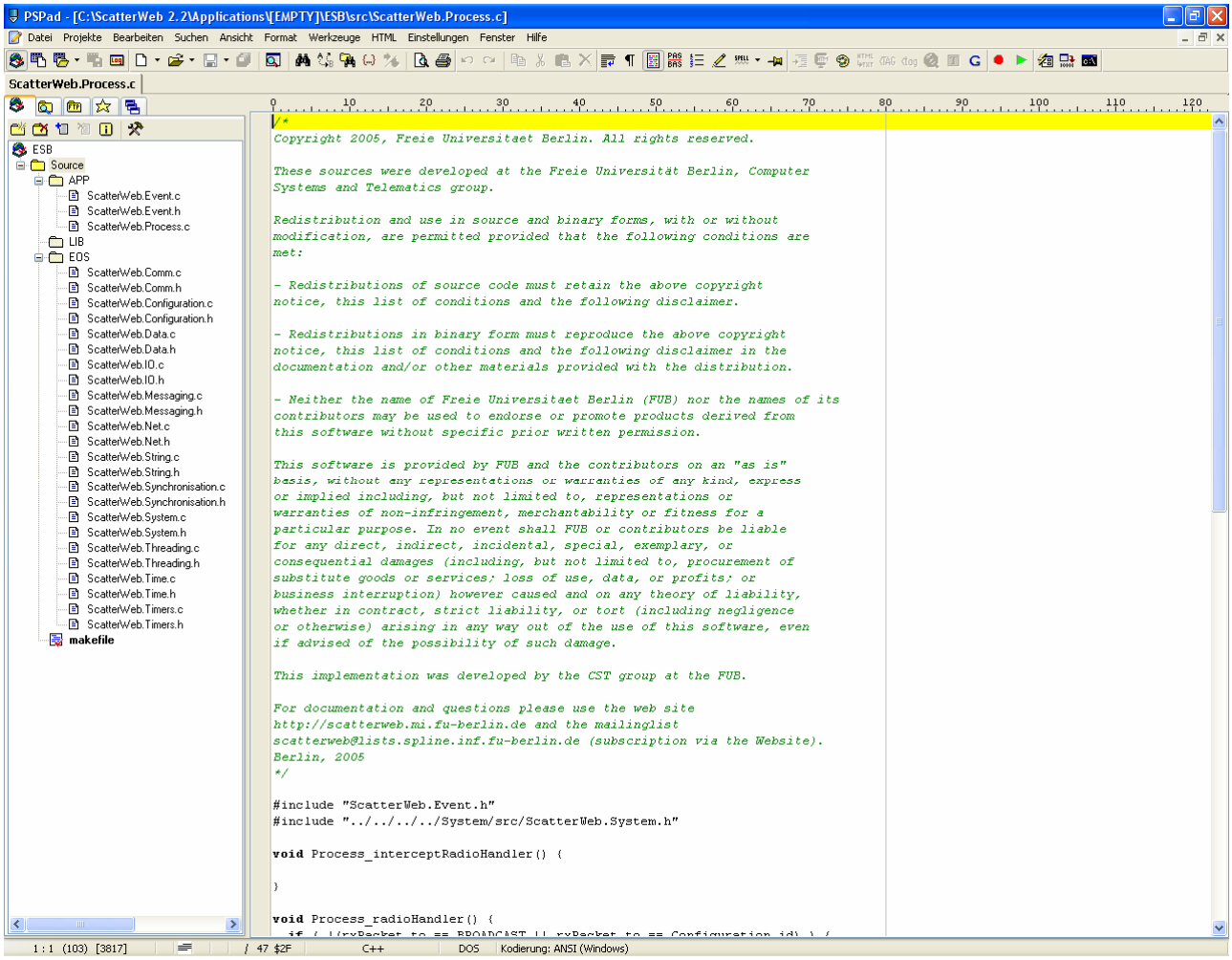
   ;C:\MSP430\IAR Systems;C:\MSP430\
   IAR Systems\430\bin;C:\MSP430\mspgcc\bin
   (You can find this at the following location: My Computer/Properties/Advanced/Environment Variables)
4. Execute C:\MSP430\mspgcc\giveio\install_giveio.bat

   (Driver needed running WinXP/2000 to directly access the parallel port - otherwise the gdb proxy will not run)

Usage:

After starting PSPad you can open the project files with a double click. The rightmost button in the tool bar starts the compilation. The second rightmost button with the selection "flash" can flash the project. For debugging, please start "start gdb" first (second rightmost button), then execute "run insight". If you add new files please don't forget to add them to the Makefile, too.

4.3 How to use


PSPad - [C:\ScatterWeb 2.2\Applications\[EMPTY]\ESB\src\ScatterWeb.Process.c]
Datei Projekte Bearbeiten Suchen Ansicht Format Werkzeuge HTML Einstellungen Fenster Hilfe
ScatterWeb.Process.c
ESB
Source
APP
ScatterWeb.Event.c
ScatterWeb.Event.h
ScatterWeb.Process.c
LIB
EOS
ScatterWeb.Comm.c
ScatterWeb.Comm.h
ScatterWeb.Configuration.c
ScatterWeb.Configuration.h
ScatterWeb.Data.c
ScatterWeb.Data.h
ScatterWeb.IO.c
ScatterWeb.IO.h
ScatterWeb.Messaging.c
ScatterWeb.Messaging.h
ScatterWeb.Net.c
ScatterWeb.Net.h
ScatterWeb.String.c
ScatterWeb.String.h
ScatterWeb.Synchronisation.c
ScatterWeb.Synchronisation.h
ScatterWeb.System.c
ScatterWeb.System.h
ScatterWeb.Threading.c
ScatterWeb.Threading.h
ScatterWeb.Time.c
ScatterWeb.Time.h
ScatterWeb.Timers.c
ScatterWeb.Timers.h
makefile
/*
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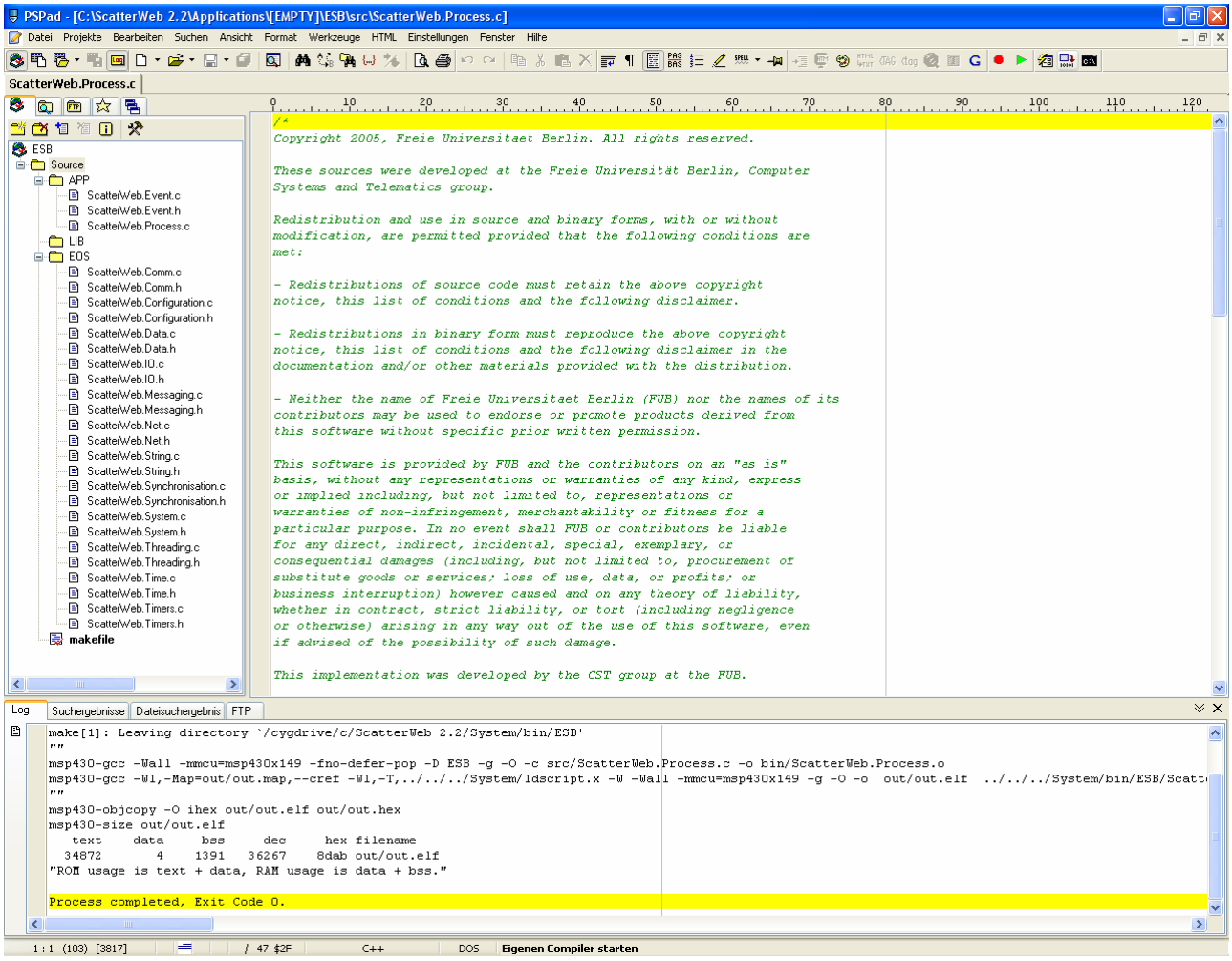
This implementation was developed by the CST group at the FUB.
For documentation and questions please use the web site
http://scatterweb.mi.fu-berlin.de and the mailinglist
scatterweb@lists.spline.inf.fu-berlin.de (subscription via the Website).
Berlin, 2005
*/
#include "ScatterWeb.Event.h"
#include "../../../../System/src/ScatterWeb.System.h"
void Process_interceptRadioHandler() {
}
void Process_radioHandler() {
1 : 1 (103) [3817]
C++
DOS
Kodierung: ANSI (Windows)

4.4 How to compile


PSPad - [C:\ScatterWeb 2.2\Applications\[EMPTY]\ESB\src\ScatterWeb.Process.c]
Datei Projekte Bearbeiten Suchen Ansicht Format Werkzeuge HTML Einstellungen Fenster Hilfe
ScatterWeb.Process.c
ESB
Source
APP
ScatterWeb.Event.c
ScatterWeb.Event.h
ScatterWeb.Process.c
LIB
EOS
ScatterWeb.Comm.c
ScatterWeb.Comm.h
ScatterWeb.Configuration.c
ScatterWeb.Configuration.h
ScatterWeb.Data.c
ScatterWeb.Data.h
ScatterWeb.IO.c
ScatterWeb.IO.h
ScatterWeb.Messaging.c
ScatterWeb.Messaging.h
ScatterWeb.Net.c
ScatterWeb.Net.h
ScatterWeb.String.c
ScatterWeb.String.h
ScatterWeb.Synchronisation.c
ScatterWeb.Synchronisation.h
ScatterWeb.System.c
ScatterWeb.System.h
ScatterWeb.Threading.c
ScatterWeb.Threading.h
ScatterWeb.Time.c
ScatterWeb.Time.h
ScatterWeb.Timers.c
ScatterWeb.Timers.h
makefile
/*
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if advised of the possibility of such damage.
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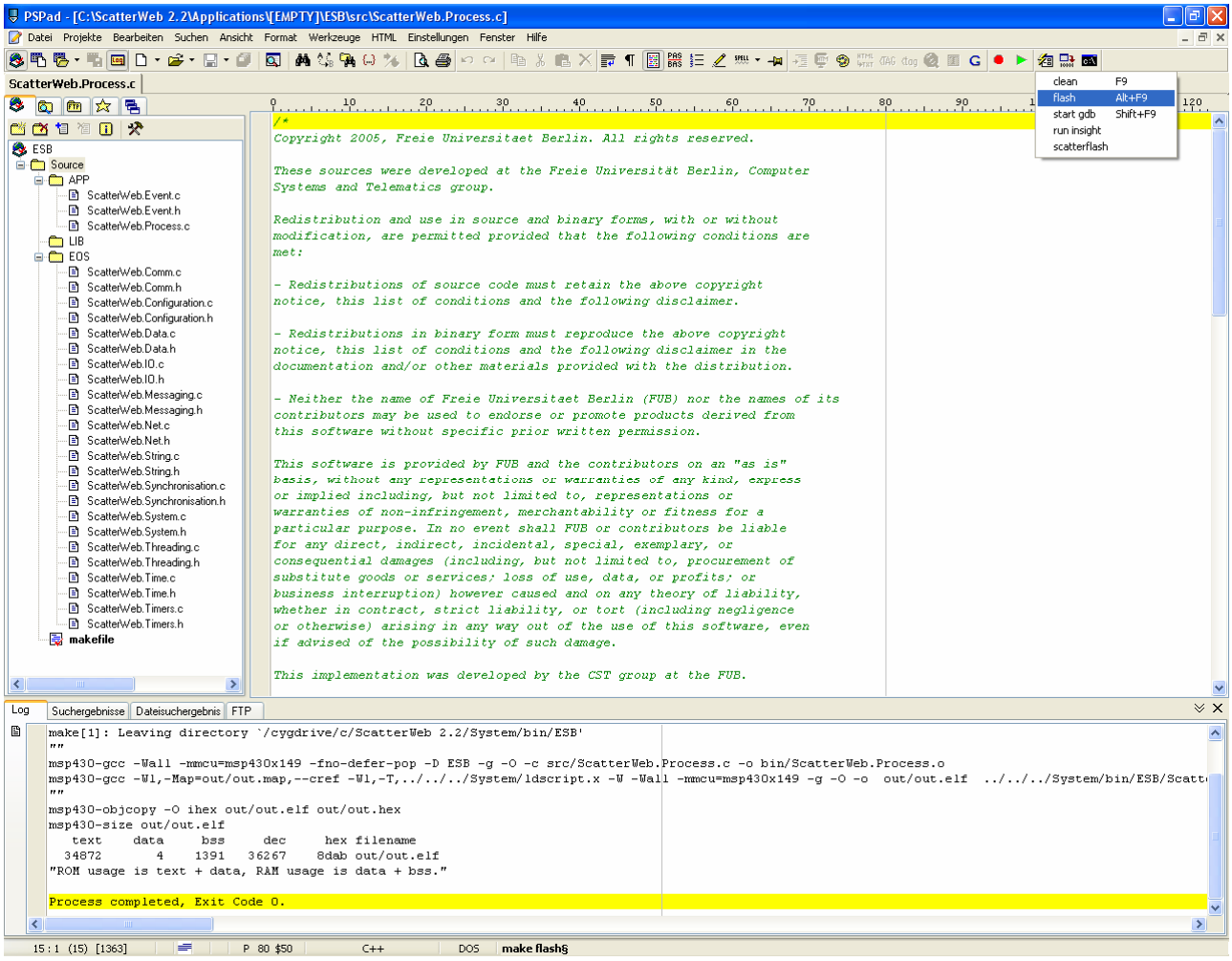
Log
Suchergebnisse
Dateisuchergebnis
FTP
make[1]: Leaving directory `/cygdrive/c/ScatterWeb 2.2/System/bin/ESB'
""
msp430-gcc -Wall -mmcu=msp430x149 -fno-defer-pop -D ESB -g -O -c src/ScatterWeb.Process.c -o bin/ScatterWeb.Process.o
msp430-gcc -Wl,-Map=out/out.map,--cref -Wl,-T,../../../System/ldscript.x -W -Wall -mmcu=msp430x149 -g -O -o out/out.elf ../../../System/bin/ESB/Scatt
""
msp430-objcopy -O ihex out/out.elf out/out.hex
msp430-size out/out.elf
text data bss dec hex filename
34872 4 1391 36267 8dab out/out.elf
"ROM usage is text + data, RAM usage is data + bss."
Process completed, Exit Code 0.
1 : 1 (103) [3817]
/ 47 $2F
C++
DOS
Eigenen Compiler starten

4.5 How to flash


PSPad - [C:\ScatterWeb 2.2\Applications\[EMPTY]\ESB\src\ScatterWeb.Process.c]
Datei Projekte Bearbeiten Suchen Ansicht Format Werkzeuge HTML Einstellungen Fenster Hilfe
ScatterWeb.Process.c
clean F9
flash Alt+F9
start gdb Shift+F9
run insight
scatterflash
ESB
Source
APP
ScatterWeb.Event.c
ScatterWeb.Event.h
ScatterWeb.Process.c
LIB
EOS
ScatterWeb.Comm.c
ScatterWeb.Comm.h
ScatterWeb.Configuration.c
ScatterWeb.Configuration.h
ScatterWeb.Data.c
ScatterWeb.Data.h
ScatterWeb.IO.c
ScatterWeb.IO.h
ScatterWeb.Messaging.c
ScatterWeb.Messaging.h
ScatterWeb.Net.c
ScatterWeb.Net.h
ScatterWeb.String.c
ScatterWeb.String.h
ScatterWeb.Synchronisation.c
ScatterWeb.Synchronisation.h
ScatterWeb.System.c
ScatterWeb.System.h
ScatterWeb.Threading.c
ScatterWeb.Threading.h
ScatterWeb.Time.c
ScatterWeb.Time.h
ScatterWeb.Timers.c
ScatterWeb.Timers.h
makefile
/*
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Log
Suchergebnisse
Dateisuchergebnis
FTP
make[1]: Leaving directory `/cygdrive/c/ScatterWeb 2.2/System/bin/ESB'
""
msp430-gcc -Wall -mmcu=msp430x149 -fno-defer-pop -D ESB -g -O -c src/ScatterWeb.Process.c -o bin/ScatterWeb.Process.o
msp430-gcc -Wl,-Map=out/out.map,--cref -Wl,-T,../../../System/ldscript.x -W -Wall -mmcu=msp430x149 -g -O -o out/out.elf ../../../System/bin/ESB/Scatt
""
msp430-objcopy -O ihex out/out.elf out/out.hex
msp430-size out/out.elf
text data bss dec hex filename
34872 4 1391 36267 8dab out/out.elf
"ROM usage is text + data, RAM usage is data + bss."
Process completed, Exit Code 0.
15 : 1 (15) [1363]
P 80 $50
C++
DOS
make flash§

Appendix A – Terminal Command Listing

Command	Parameter	Description	Location
app		read the name of the application	ScatterWeb.Process
brt	x	init Comm with x bps Valid values are: 01 = BPS_2400 02 = BPS_14400 03 = BPS_19200 04 = BPS_38400 05 = BPS_57600 06 = BPS_115200	ScatterWeb.Comm
dco	x	if x==+ set dco++, if x==- set dco—	ScatterWeb.Messaging
dea		erase eeprom	ScatterWeb.IO
dsr		set flags to print no sensor data to none	ScatterWeb.Event
esr		set flags to print sensor data to radio	ScatterWeb.Event
est		prints software header of image	ScatterWeb.System
flx	x…y	broadcasting a userapp from x to y	ScatterWeb.System
fst		prints running software header	ScatterWeb.System
lst		list commands	ScatterWeb.Messaging
mem		read free stack bytes	ScatterWeb.Messaging
pan	x	set panic flag x	ScatterWeb.Messaging
pcl		clear panic and reset system	ScatterWeb.Messaging
png	x	send ping packet to x	ScatterWeb.Messaging
prr		read panic reason	ScatterWeb.Configuration
raf		read announce flags	ScatterWeb.Event
rbu		read button state	ScatterWeb.Messaging
rcf		read configuration	ScatterWeb.Configuration
rer	x y	read eeprom from x to y	ScatterWeb.IO
rff		read firmware flags	ScatterWeb.Configuration
rfl	x y	read flash from x to y	ScatterWeb.IO
rfr		read receive limit	ScatterWeb.Messaging

rid		read id	ScatterWeb.Configuration
rlb		read boot log level	ScatterWeb.Configuration
rlg		read green led state	ScatterWeb.Messaging
rlo		read log level	ScatterWeb.Configuration
rlr		read red led state	ScatterWeb.Messaging
rly		read yellow led state	ScatterWeb.Messaging
rmm		read microphone value	ScatterWeb.Messaging
rpf		read panic flags	ScatterWeb.Configuration
rrp		read temp rxp	ScatterWeb.Messaging
rsm		read sensor mask	ScatterWeb.Event
rsp		read stack pointer	ScatterWeb.Messaging
RST		reset system	ScatterWeb.Messaging
rtp		read transmit power	ScatterWeb.Messaging
rtt		read temperature	ScatterWeb.System
rvb		read battery value	ScatterWeb.Messaging
rve		read extern value	ScatterWeb.Messaging
saf	x	set announce flags Valid values are: 01 = AF_SERIAL 02 = AF_RADIO or a combination of this values	ScatterWeb.Event
sbp	x	if x==1 beeper on, otherwise off	ScatterWeb.Messaging
scf		set standard configuration	ScatterWeb.Configuration
sco		read tasks	ScatterWeb.Threading
sff	x	set firmware flags Valid values are: 01 = FF_PROGRAMMABLE 02 = FF_DCOCHECKER or a combination of this values	ScatterWeb.Configuration
sfr	x	set receive limit	ScatterWeb.Messaging
sid	x	set id to x	ScatterWeb.Configuration

sir	x	send x over RC5	ScatterWeb.Messaging
slb	x	set boot log level Valid values are: 01 = NO 02 = LOW 03 = MEDIUM 04 = HIGH 05 = VERBOSE 20 = DEBUG_SYNC 40 = DEBUG_DCO 80 = DEBUG_RADIO or a combination of this values	ScatterWeb.Configuration
slg	x	if x==1 set green led on, otherwise off	ScatterWeb.Messaging
slo	x	set log level Valid values are: 01 = NO 02 = LOW 03 = MEDIUM 04 = HIGH 05 = VERBOSE 20 = DEBUG_SYNC 40 = DEBUG_DCO 80 = DEBUG_RADIO or a combination of this values	ScatterWeb.Configuration
slr	x	if x==1 set red led on, otherwise off	ScatterWeb.Messaging
sly	x	if x==1 set yellow led on, otherwise off	ScatterWeb.Messaging
spf	x	set panic flags Valid values are: 01 = PANIC_ON_STACK_OVERFLOW 02 = PANIC_ON_FULL_TIMERS	ScatterWeb.Configuration

		04 = PANIC_ON_BAD_RESET 80 = PANIC_DISABLES_APP or a combination of this values	
ssm	x	set sensor mask to x Valid values are: 01 = SENSOR_MICROPHONE 02 = SENSOR_TEMPERATURE 04 = SENSOR_RC5 08 = SENSOR_MOVEMENT 10 = SENSOR_VIBRATION 40 = SENSOR_VOLTAGE 80 = SENSOR_BUTTON or a combination of this values	ScatterWeb.Event
stp	x	set transmit power to x	ScatterWeb.Messaging
swg		toggle green led	ScatterWeb.Messaging
swr		toggle red led	ScatterWeb.Messaging
swy		toggle yellow led	ScatterWeb.Messaging
tim		read system time	ScatterWeb.Messaging
tis	x	set system time to x seconds	ScatterWeb.Messaging
tiz	x	set system time to x milliseconds	ScatterWeb.Messaging
tmr		read timers	ScatterWeb.Timers
web	x y	write y at x of eeprom	ScatterWeb.IO

Appendix B – Terminal Command Availability

Command	ECR	ESB	EYE	eGate/USB	eGate/WEB
app	x	x	x	x	x
brt	x	x	x	x	x
dco	x	x	x	x	x
dea	x	x	x	x	x
dsr	x	x	x	x	x
esr	x	x	x	x	x
est	x	x	x	x	x
flx	x	x	x	x	x
fst	x	x	x	x	x
lst	x	x	x	x	x
mem	x	x	x	x	x
pan	x	x	x	x	x
pcl	x	x	x	x	x
png	x	x	x	x	x
prr	x	x	x	x	x
raf	x	x	x	x	x
rbu	-	x	x	-	-
rcf	x	x	x	x	x
rer	x	x	x	x	x
rff	x	x	x	x	x
rfl	x	x	x	x	x
rfr	x	x	x	x	x
rid	x	x	x	x	x
rlb	x	x	x	x	x
rlg	-	x	x	x	x
rlo	x	x	x	x	x
rlr	x	x	x	x	x
rly	-	x	x	x	x
rmm	-	x	x	-	-

rpf	x	x	x	x	x
rrp	x	x	x	x	x
rsm	x	x	x	x	x
rsp	x	x	x	x	x
RST	x	x	x	x	x
rtp	x	x	x	x	x
rtt	x	x	x	-	-
rvb	-	x	x	-	-
rve	-	x	x	-	-
saf	x	x	x	x	x
sbp	-	x	x	-	-
scf	x	x	x	x	x
sco	x	x	x	x	x
sff	x	x	x	x	x
sfr	x	x	x	x	x
sid	x	x	x	x	x
sir	-	x	x	-	-
slb	x	x	x	x	x
slg	-	x	x	x	x
slo	x	x	x	x	x
slr	x	x	x	x	x
sly	-	x	x	x	x
spf	x	x	x	x	x
ssm	x	x	x	x	x
stp	x	x	x	x	x
swg	-	x	x	x	x
swr	x	x	x	x	x
swy	-	x	x	x	x
tim	x	x	x	x	x
tis	x	x	x	x	x
tiz	x	x	x	x	x
tmr	x	x	x	x	x
web	x	x	x	x	x